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EDITORIAL

In the recent election of Professor Charles Fuller Baker to the deanship of the College of Agriculture, the Board of Regents of the University has again displayed its wisdom in judging men's qualities. As professor of agronomy and chief of that important department in this college prior to his departure to Singapore, Professor Baker enjoyed the confidence and respect of the students and of his fellow members of the faculty by the broadness of his views, such as anyone would expect of a man of his experience and training, by his frank and straight-forward manner in dealing with everybody, and by his strict attention to business, which is best explained, if we may be permitted to use his own oft-repeated expression, by the phrase "hold it down to brass tacks." Professor Copeland has always held Professor Baker in high esteem; and we are sure that our former dean cannot be better pleased than with the appointment of this worthy successor, for then Professor Copeland can rest assured that the institution for which he labored for many years is entrusted to safe hands.

The new dean has behind him an experience of about a quarter of a century in tropical agronomy, by his long residence as a worker along this line in many of the more importat agricultural countries of tropical America, and, later, in the Philippines and in Singapore. Although officially known only as an agronomist, Professor Baker is, at the same time, well recognized in the scientific world as an entomologist, zoologist, plant pathologist and mycologist, and botanist. During his spare hours, outside of his official duties, he has found a pleasurable, as well as highly useful, pastime in privately carrying on scientific investigation. He is an indefatigable worker, and men who had the privilege of being closely associated with him know too well how very often, by his working table in his residence, he is seen absorbed in the study of some new or interesting insect or fungus till long after midnight. On Sundays and holidays he has found rest in being temporarily relieved of his regular official obligations and in thus being able to devote more time to his scientific research.

In the four years that Professor Baker remained in the Philippines, he accumulated, entirely by his own effort and at his own expense, an extensive collection comprising thousands of species of Philippine insects, plant diseases and botanical materials. Many of these specimens proved to be new to science. He has prepared an enormous number of manuscripts bearing on little known insects and plant diseases of the Philippines; and, according to the information we have succeeded in getting, only a very small part of his writing has as yet been published. Professor Baker is to a large extent responsible for the present fairly advanced condition of knowledge in the science of plant pathology in the Philippines. His work in the Philippine entomology is, likewise, incalculable.

The faculty and the student body of this college are anxious to be given the opportunity soon to welcome once more their old professor and new dean. They will be but too glad to enjoy again the benefit of his valuable counsel and help in their difficulties. THE PHILIPPINE AGRICULTURIST AND FORESTER, as an official organ of the College of Agriculture, wishes Professor Baker a safe return to the Philippines, and a long and successful administration of this institution.

Yautia and Gabi Tests

By Francisco A. Abadilla

Thesis presented for graduation from the College of Agriculture, No. 79.

INTRODUCTION

In the Philippines, the gabis and dasheens are usually planted for family use in the back-yards of homes, along river banks and in swampy places. The plants are set close and at irregular intervals and, after planting, no more attention is given them in the way of weeding, irrigation and cultivation.

The yautias have recently been introduced from the American tropics and have been found to do well in some parts of the Philippines. They rank with sweet potatoes as to nutritiousness, and the digestive principles contained in them render their roots a perfectly safe diet. They are less susceptible to the destructive diseases to which the gabis and dasheens are subject. They are much more productive and more resistant to drought. Where the gabis and dasheens do well, the yautias will do better. It remains yet to be seen how these crops will behave under different conditions of treatment in field culture. The object of the present study was to compare the reaction of yautias, gabis and dasheens to different cultural treatment, but due to the lack of sprouts of gabis and dasheens it was only possible to use the yautias in the field cultures.

CULTIVATION

The best soil for the aroids is a sandy loam with an abundance of organic matter. The plant does not do well in clayey soils and it does not thrive in pure sand. In Bombay the crop is rarely grown over a large area. Patches are raised in the back yards of houses, and in the garden lands of Gujarat it is common to find a patch near a well, and with single plants at the corners of beds of other irrigated crops. When grown alone, the land is carefully prepared, and laid out into beds 12 feet by 6 feet for irrigation. Forty plants occupy each bed. If the corns are desired they are set 12 inches apart. The leaves and stalks can be gathered every 3 to 4 days after 4 to 5 months from the time of planting. In Caunpore district, the average yield is about 2000 pounds per acre, but in Coimbatore, however, the yield has been recorded as 6,250 pounds per acre. (1).

In South Malabar germinated seeds are generally set out. The seeds are kept in loose soil nursery for two weeks and slightly watered daily. In February to March germinated tubers are set out in circular pits more than a foot in diameter and 9 inches deep, the distance from the center of one pit to another being 3 feet. Three to four tubers are planted in each pit, which is fertilized at the rate of 5 pounds of cattle manure at planting, 2 pounds after 30 days and 2 pounds of cattle manure and 2 to 3 pounds of green leaves in June. At the base of the plant earth is thrown up. Ashes are frequently mixed with the manure at the second and third manuring. Hand watering is given once in 4 or 5 days till the beginning of the rainy season. No further attention is given until the crop is harvested in August. (2)

In the Philippines the gabis and dasheens are cultivated in a haphazard way. No system of planting is followed. The plants are set very close and consequently the production is low. The planting is usually at irregular intervals and, because of close spacing, animal cultivation is impossible. When

planted on level places where the soil is rich and porous, the produce is greater. Throwing earth around the plant increases the production as much as 20 per cent. (3) In Porto Rico the common people cultivate the yautias in much the same way as the people in the Philippines do the gabis and dasheens. The soil is not prepared well and the plants are set very closely and at irregular intervals. They are not planted over large areas, although they rank third among the staple foods of the people. The yield is two to four times that of the potato or from 5 to 10 tons per acre. (4) In the Experiment Station at Porto Rico a great deal of experimenting is done towards the improvement of the gabis, yautias and dasheens. The experiments include ridge versus level planting, large versus small tubers for planting, distance plantings, fertilizers, and variety tests. (5)

The taro (*Colocasia*) was the main source of food of the Hawaiians before the advent of civilization and now even the white population find it nutritious and palatable. There are two distinct varieties, the upland and the lowland varieties. The upland varieties are found to thrive only in the rainy districts. The lowland varieties are planted along streams and are ready to harvest in one year. (6)

Under ordinary conditions in the tropics, the aroids can be planted during any season of the year. The best time, however, is at the beginning of the rainy season, because then the plants will have a good start.In the Philippines, the best time to plant is during the months of May or June. The time of harvest depends upon the variety. The dasheens are ready to harvest in 5 to 8 months, the gabis and the yautias in one year, and the *Alocasias* and *Cystospermas* in 1½ to 2 years. (3) Spacing depends also upon the variety. The smaller varieties require a distance of one meter and the larger varieties of 1 to 2 meters each way. In rich alluvial soil 5000 to 10,000 plants can be planted in an acre. In fairly dry soil closer planting is advisable. (7) In this kind of soil, O W. Barrett recommends a spacing of 3 feet each way to allow animal cultivation of the young plants.

For seed the tubers, the tops of the rootstocks and the *madres* may be used. (7) Sections of the rhizome can be used also, provided that they have two or more buds. Actual experiments, however, have shown the advisability of using only the tops of the old rootstocks. They develop earlier and produce more tubers in shorter time than when cuttings or tubers are used. By using the latter the yields is reduced as much as 15 to 20 percent. (8)

FERTILIZERS

The yautias, gabis and dasheens, being heavy producers, need a fertile soil. O. W. Barrett of the Porto Rico Experiment Station found that stable manure gave the best results. Well-rotted coffee pulp when applied to an ordinary soil increased the production by 12.4 tons per care. Chemical nitrates and phosphates did not give good results. Chemical nitrates tend to produce heavy tubers of enormous size but low in carbohydrates. Nitrogen in the form of ammonium salts is utilized readily. (7)

HARVESTING

Harvesting and the subsequent cleaning and sorting are the most difficult part of the operation. It is even more costly than the harvesting of either potatoes or sweet potatoes. In this particular crop, hand labor is used in harvesting. The mattock and the pick have been found to be very convenient

for this purpose. The soil is first removed around the plant and the bundle of leafstalks grasped and pulled. Any tuber breaking away can be easily dug by a blow of the mattock or pick. A 10-inch plow has also been found very convenient for harvesting.

In the West Indies a good system is used in increasing the production of the crop. The method is called castration, and consists in removing the soil around the plant and then taking the ripe tubers for use. The soil is then put back. In eighteen to twenty-four months as much as 30 tons can be harvested from one acre.

DISEASES

The thick acrid juice which is found in all parts of the plant seems to protect the yautias against fungus, bacterium, and insect attacks under ordinary conditions. The tubers, however, have two or three diseases causing them to rot. This rotting is due partly to fungi and bacteria. There is at least one species of moths (*Hippotion celerio* Linn.) the larvae of which feed upon the gabi leaves. They defoliate the plants at times. However, these leaf pests were not met with in the present work, which fact tends to show that they occur only at rare intervals.

THE PRESENT WORK

The object of the present study is to make a careful comparison of the behavior of the yautias, gabis and dasheens under different conditions of culture. The complete plan of the work is as follows:

I. Previous work on cultural methods of yautias, gabis and dasheens (abstracts with records of yield).
II. Planting all varieties in an open field on the farm.
   (a) One meter by one meter distance
   (b) Spacing according to the demand of varieties.
III. The more numerous varieties compared when planted.
   (a) As an intercrop to some permanent planting.
   (b) On the plateau.
   (c) In a well cared for caiñgin.
   (d) In the coffee plantation.
   (e) In an uncleared and uncultivated caiñgin.

The seeds used in this experiment were from the previous harvest on the college farm. The *madres*, the base of the *madres* and the tubers were used for seed. The small tubers were planted whole and the larger ones cut into halves. The base of the *madres* were also cut into pieces varying from 100 to 200 grams a piece. Each piece bore one or more buds. This cutting was resorted to in order to provide enough seeds to supply all the cultures. There were 12 varieties of yautias, 8 of gabis, and 4 of dasheens used in this study.

On May 12, 1916, the seeds were germinated in beds under shade. Sprinkling water every other day was found convenient to keep the ground moist and help the germination of the seeds. Within two weeks, most of the seeds sprouted. The first field was planted May 18, 1916, and the last July 1, 1916. The plan was to have all the fields planted on the same day, but it was found impossible to do so, because the land could not all be made ready at the same time. Two distances were used in planting. One was 1 by 1 meter and the other 1.5 by 1.5 meters. In the former case 10,000 seeds and in the latter 4,444 seeds were needed per hectare. Only germinated seeds were used in these cultures.

The first field to be planted was under a coconut grove. It was found rather hard to prepare the soil due to the presence of large numbers of coconut

roots which interfered greatly with plowing and harrowing. Two plowings and harrowings were needed to bring the land into shape. The soil is clay loam. The surface soil varies from 3 to 5 inches deep. The plants were set in rows one meter apart. The depth of planting varied from 5 to 7 inches.

The open field was planted on the same day. Here, no difficulty was encountered in preparing the land, because it had been in continued planting to corn, rice and cane. The soil is loose clay loam and the surface soil is at least seven inches deep. Here two spacings were used 1 by 1 meter and 1.5 by 1.5 meters. The gabis and dasheens were all planted 1 by 1 meter, because seeds of these could not be had in large quantities. In all other plantings, 1 meter each way was used as the standard distance.

The well-cared for *caingin* and the uncleared and uncultivated *caingin* were planted May 23 and May 25, respectively. Some stumps had to be dug out in order to set the plants 1 by 1 meter each way.

At the coffee plantation, logs had to be cut into short pieces and carried away before any planting could be done. This plantation is about half-way between the College of Agriculture and the top of Mount Maquiling. It has an altitude of approximately 400 meters. The climate is cool all the year round and the atmosphere is humid. The soil is rich, loose clay loam. Planting was done May 30, 1916, and the plants were set between the rows of coffee. The place is well shaded with large trees and receives sunlight only in the latter part of the afternoon.

On the plateau, at medium elevation, a level spot was selected which was free from stumps. It is about 75 meters above the sea level. The soil is clay loam which is compact because the land is being used for pasture. The surface soil varies from 3 to 7 inches deep. The compactness of the soil coupled with the presence of the roots of the closely grazed cogon proved too hard for a plow drawn by a single vaca. So a big plow drawn by three vacas was used. After harrowing, the plants were set in July 1, 1916.

CULTIVATION

During the first month after planting, it was found necessary to go once a week over the fields to cultivate them in order to eradicate the weeds, and also to conserve the soil moisture. During the second and third month, bi-weekly weeding had to be done, and thereafter up to the time af harvesting monthly weeding was found sufficient. When the plants were developed, monthly cultivation, or even less frequent, was sufficient because their leaves shaded the ground and prevented the rapid growth of weeds. Shaded yautias required even less care. In fact, the yautias in the coconut grove and at the coffee plantation required only one cleaning after the third month of culture.

RESULTS

The crops were harvested at the age of seven months. For the yautias, separate weighings were made of the tubers and *madres* because the *madres* are not edible. In the gabis and dasheens, the whole rootstock was weighed less the stem, because both the *madres* and tubers are edible. Following are the tables of yields of the different fields.

TABLE I

OPEN FIELD PLANTED 1×1 METER

Field No.	Variety	Yield per hectare of madres Kilograms	Kilograms yield per hectare of tubers	Average yield per hill Kilograms	Total production per hectare Kilograms
	YAUTIAS				
309	Rolliza Blanca Yautia	7,396	15,832	2.323	23,228
434	White Tamma Yautia	3,547	14,570	1.812	18,117
436	Punyera Yautia	3,340	9,180	1.252	12,520
439	Trinidad Yautia	2,671	9,719	1.239	12,390
442	Taro Royal Yautia	8,854	13,787	2.264	22,641
443	Grey Jack Yautia	3,350	10,672	1.402	14,022
444	Rolliza Yautia	5,544	15,644	2.119	21,188
586	Unknown Yautia	3,867	13,734	1.760	17,601
588	Unknown Yautia	4,235	14,323	1.856	18,558
589	Unknown Yautia	3,913	21,013	2.493	24,496
1678	Unknown Yautia	8,910	24,295	3.321	33,205
??	Unknown Yautia	5,729	11,541	1.727	17,270
	DASHEENS				
5768	Tangad or Manolod Dasheen			.1864	1,864
5780	Unknown Dasheen			.4250	4,250
5777	Unknown Dasheen			.520	5,200
5770	Unknown Dasheen			.2225	2,225
	GABIS				
495	Mindoro Gabi			.5127	5,217
5769	Gabi Siniñora			.1680	1,680
5767	Gabi Bongcocan			.1100	1,100
5771	Unknown Gabi			.3200	3,200
5774	Unknown Gabi			.3875	3,875
5775	Unknown Gabi			.310	3,100
5776	Unknown Gabi			.2975	2,975
5778	Unknown Gabi			.1267	1,267

TABLE II

OPEN FIELD PLANTED 1.5×1.5 METERS

Field No.	Variety	Yield per hectare of madres Kilograms	Yield per hectare of tubers Kilograms	Average yield per hill Kilograms	Total production per hectare Kilograms
309	Rolliza Blanca Yautia	4,780	10,177	3.365	14,957
434	White Tamma Yautia	2,066	9,021	2.494	11,087
436	Punyera Yautia	2,044	4,177	1.399	6,221
439	Trinidad Yautia	1,644	6,177	1.759	7,821
442	Taro Royal Yautia	4,488	6,133	2.389	10,621
443	Grey Jack Yautia	3,111	8,444	2.600	11,555
444	Rolliza Yautia	2,311	5,510	1.757	7,821
586	Unknown Yautia	2,622	10,355	2.920	12,977
588	Unknown Yautia	3,777	6,799	2.399	10,576
589	Unknown Yautia	2,400	8,000	2.340	10,399
1678	Unknown Yautia	2,622	8,577	3.420	15,199
?	Unknown Yautia	4,311	7,066	2.560	11,377

TABLE III

IN COCONUT GROVE OR AS INTERCROP AMONG COCONUTS

Field No.	*Variety*	*Yield per hectare of madres Kilograms*	*Yield per hectare of tubers Kilograms*	*Average yield per hill Kilograms*	*Total production per hectare Kilograms*
309	Relliza Blanca Yuatia	6,916	19,092	2.600	26,008
436	Punyera Yautia	3,120	13,700	1.682	16,820
439	Trniidad Yautia	2,950	11,950	1.490	14,900
442	Taro Royal Yautia	4,421	14,267	1.869	18,688
443	Grey Jack Yautia	2,845	11,315	1.416	15,160
444	Rolliza Yautia	3,979	13,754	1.773	17,733
586	Unknwon Yautia	3,143	9,829	1.299	12,986
588	Unknown Yautia	5,076	16,353	2.143	21,429
589	Unknown Yautia	5,100	16,773	2.187	21,873
1678	Unknown Yautia	4,185	17,560	2.175	21,745

TABLE IV

ON THE PLATEAU

Field No.	*Variety*	*Yield per hectare of madres Kilograms*	*Yield per hectare of tubers Kilograms*	*Average yield per hill Kilograms*	*Total production per hectare Kilograms*
309	Rolliza Blanca Yautia	5,276	14,088	1.936	19,364
436	Punyera Yautia	1,314	15,000	1.631	16,314
439	Trinidad Yautia	3,510	15,430	1.894	18,940
442	Taro Yoyal Yautia	6,556	16,300	2.286	22,856
443	Grey Jack Yautia	4,716	18,056	2.277	22,772
444	Rolliza Yautia	4,580	16,804	2.138	21,384
586	Unknown Yautia	3,029	15,686	1.872	18,715
588	Unknown Yautia	5,376	15,238	2.061	20,614
589	Unknown Yautia	4,808	21,308	2.612	26,116
1678	Unknown Yautia	3,926	19,252	2.318	23,178

TABLE V

IN WELL CARED FOR CAINGIN

Field No.	*Variety*	*Yield per hectare of madres Kilograms*	*Yield per hectare of tubers Kilograms*	*Average yield per hill Kilograms*	*Total production per hectare Kilograms*
309	Rolliza Blanca Yautia	11,300	20,224	2.135	21,354
436	Punyera Yautia	15,530	17,640	2.317	23,170
439	Trinidad Yautia	6,880	15,920	2.280	22,800
442	Taro Royal Yautia	7,527	15,400	2.293	22,927
443	Grey Jack Yautia	8,905	19,590	2.850	28,495
444	Rolliza Yautia	8,514	16,682	2.520	25,196
586	Unknown Yautia	6,900	19,629	2.653	26,529
588	Unknown Yautia	6,388	18,600	2.499	24,988
589	Unknown Yautia	5,400	19,800	2.520	25,205
1678	Unknown Yautia	5,920	20,815	2.674	26,735

TABLE VI

AT THE COFFEE PLANTATION

Field No.	*Variety*	*Yield per hectare of madres Kilograms*	*Yield per hectare of tubers Kilograms*	*Average yield per hill Kilograms*	*Total production per hectare Kilograms*
309	Rolliza Blanca Yautia	3,760	14,056	1.782	17,816
436	Punyera Yautia	866	7,367	0.823	8,233
439	Trinidad Yautia	2,083	14,583	1.667	16,666
442	Taro Royal Yautia	3,628	9,272	1.290	12,900
443	Grey Jack Yautia	1,750	11,130	1.288	12,880
444	Rolliza Yautia	2,500	12,900	1.540	15,400
586	Unknown Yautia	1,163	8,367	.953	9,530
588	Unknown Yautia	2,212	13,529	1.574	15,741
589	Unknown Yautia	1,979	15,536	1.752	17,515
1678	Unknown Yautia	3,370	17,640	2.101	21,010

TABLE VII

IN AN UNCLEARED AND UNCULTIVATED CAINGIN

Field No.	*Variety*	*Yield per hectare of madres Kilograms*	*Yield per hectare of tubers Kilograms*	*Average yield per hill Kilograms*	*Total production per hectare Kilograms*
309	Rolliza Blanca Yautia	6,988	11,352	1.834	18,340
436	Punyera Yautia	4,044	6,178	1.022	10,222
439	Trinidad Yautia	4,568	11,174	1.573	15,732
442	Taro Royal Yautia	5,674	8,311	1.399	13,985
443	Grey Jack Yautia	5,115	11,990	1.711	17,105
444	Rolliza Yautia	7,446	9,983	1.743	17,429
586	Unknown Yautia	4,814	7,186	1.200	12,000
588	Unknown Yautia	7,124	11,706	1.883	18,830
589	Unknown Yautia	6,427	10,867	1.729	17,294
1678	Unknown Yautia	3,448	12,505	1.595	15,953

The tables show the wide range of variation in the yield of the different varieties of yautias under either different or the same field conditions. Of the gabis and dasheens, the results obtained were unsatisfactory. Of the twelve varieties cultivated, not one of them gave an average of 1 kilo per hill. The largest yield obtained from the gabis was from variety No. 5777, which gave 5,200 kilos of rootstock per hectare. From the dasheens, variety No. 5774 gave the most which was 3875 kilos of rootstock per hectare. These are, of course, still very low and will not warrant their production as a commercial field crop. Gabis and dasheens to be profitable (a) have to yield at least 7,000 kilos of rootstock per hectare.

The yautias thrive well in the open field. It was found that a greater yield per hectare can be produced by spacing the plants one meter each way than by planting them 1.5 by 1.5 meters. By using the 1.5 by 1.5 meter spacing, the average production per hill was greater for almost all the varieties than with the 1 by 1 meter spacing, but when it comes to the total production per hectare, the 1 by 1 meter spacing yielded. more. Below is the table of comparison of the yield per hectare of the different varieties of yautias when spaced differently.

Field No.	*Variety*	*Distance 1×1 m. Total yield per hectare of root stock Kilograms*	*Distance 1×1.5 Total yield per hectare of root stock Kilograms*	*Difference Kilograms*
309	Royal Blanca Yautia	23,228	14,957	8,271
434	White Tamma Yautia	18,117	11,087	7,030
442	Taro Royal Yautia	22,641	10,621	12,020
443	Grey Jack Yautia	14,022	11,555	2,467
586	Unknown Yautia	17,601	12,977	4,624
586	Unknown Yautia	18,558	10,576	7,892
589	Unknown Yautia	24,496	10,399	14,097
1678	Unknown Yautia	33,205	15,199	18,006
?	Unknown Yautia	17,270	11,377	5,893

It is seen that a gain of from 2 to 18 tons can be made per hectare by the closer distancing. Therefore, for these varieties, spacing more than one meter is not only unnecessary but wasteful.

As a catch crop in a coconut plantation, promising results were obtained from the yautias, despite the fact that they were well shaded by the coconut trees. None of the ten varieties planted produced less than 12 tons of rootstock per hectare. The production varied

(a) The Philippine Agriculturist and Forester, Vol. III, No. 5, p. 110.

from 12 to 26 tons a hectare. The yields are quite fair under such conditions. The greatest yielders were the varieties Nos. 309, 442, 588, 589 and 1678, which gave 26,008, 18,688, 21,429, 21,873 and 21,745 kilos of rootstocks per hectare, respectively. The plants were rather stunted in growth, as could be expected under such conditions, but the production compares well with the yautias in the open field which gave from 12 to 33 tons of roots a hectare.

As a catch crop between coconut trees, yautias have therefore a promising place. They require little attention. In fact it is only necessary to cultivate them four times in seven months. Cultivation was imperative only to insure the plants a good start, for after they have outgrown the weeds their shade and that of the coconuts will keep the latter down. Yautias can be made to produce ready money because the supply of aroid root crops in the Philippines is very insufficient.

The yautias and the coconuts belong to two widely different families, and hence their demands upon the soil must be different. Of course, intercropping will wear the soil in shorter time then when one crop alone is grown. But this loss will be compensated by the profits made from the yautias. If necessary, fertilizers may be bought and applied directly to the base of the coconut trees. Intercropping is only possible when the supply of labor is ample and cheap.

If a coconut plantation is to be intercropped at all, cultivation should be practised when the coconuts are still young. This will induce the roots to go deeper into the soil and avoid the unnecessary destruction of roots when cultivation is done later. Cutting of roots destroys the normal function of the coconuts temporarily because their food supply is reduced. Spacing should also be increased when a grove is to be intercropped. When planted 8 meters each way, three rows of yautias 1 by 1 meter can be safely planted between the rows of coconuts.

On the plateau, although the land had been continuously growing cogon (*Imperata exaltata*), the yield was equally as good as that in the open fields. Some varieties which did not show up well in the open fields made better showing here. This is very interesting because cogon land is said to be hard on other plants due to certain poisons given off by the cogon roots. Below is a table of comparison of the yields of the different varieties of yautias grown on cogon land.

Field number	*Open field Distance 1×1 m. Kilos per hectare*	*Open field Distance 1×1 m. Kilos per hectare*	*Plateau Kilos per hectare*
436	12,520	6,221	16,314
439	12,390	7,821	18,940
443	14,022	11,555	22,772
586	17,601	12,977	18,715
588	18,558	10,576	20,614

Yautias, therefore, can be planted with advantage on land previously occupied by cogon. The smallest yield obtained here was 16 tons per hectare and all others gave from 18 to 26 tons a hectare.

The yautias on both the cultivated and uncultivated *caingin* lands were observed to produce long slender petioles with broad leaf blades. This was also the case of the yautias in the coffee plantation. On both *caingins*, larger madres were obtained than elsewhere among the cultures. In well-cared for *caingins*, heavier yields were obtained from every variety than in the uncultivated caingin. The gain in production varies from 3 to 14 tons a hectare. Therefore, it pays to give the plants a little more attention under such conditions.

Besides producing long slender leaves with large leaf blades, the yautias in

the coffee plantation were observed to produce smaller number of tubers than in the other cultures. This, however, was compensated by the increase in their size. The tubers were larger and thicker than those grown at the lower elevations.

SUMMARY

The yautias, gabis and dasheens are natives of the tropics. Although they have been under cultivation for hundreds of years, little has been done toward their improvement except in very few places. The best soil for them is rich, loose, sandy loam. No fixed rules can be established for distancing. The optimum distance for planting depends largely upon the variety and the kind of soil. On poor soils, closer spacing is advisable. For the smaller varieties, 0.5 meter to 1 meter may be used and for the large varieties 1 to 3 meters meters may be safely used for planting.

The different field cultures were harvested at the age of seven months. More, of course, could have been harvested had the plants been given more time to mature. Yautias and gabis mature in 8 to 12 months. There is still another factor that may affect yield and that is the indiscriminate use of seeds. The use of tubers (a) and cuttings for seed reduces the production of the plants. Hence,it is advisable to use the upper parts of the madres alone as seed when maximum production is desired.

When raising leaves for salad or as pot herb, well-cared for caiñgins will be found to be the most suitable places for growing the plants, especially when partially shaded. A fair crop of tubers could be harvested besides.

The most valuable varieties of yautias that are worth distributing throughout the Islands are those having the college numbers 309, 442, 588, 589 and 1678. Each one of them averaged at least two kilos a hill in almost all the cultures. For gabis and dasheens, a further study is needed to determine their worth. The poor yield obtained in the present experiments may be accounted by the poor quality of the seeds used and the lack of irrigation.

CONCLUSIONS

1. A greater yield per unit of area could be had from yautias if they are planted one meter each way if set one and a half by one and a half meters apart.

2. Yautias can be grown successfully between the rows of coconut trees.

3. It pays to cultivate the plants. The time spent in cultivation is compensated by the greater yield obtained.

4. Indiscriminate use of seeds is not advisable. Uniform plants and very good yield can be obtained by using selected seeds only, using the upper part of the madre.

5. Yautias can be grown with success even in higher altitudes (at least to 400 meters), other conditions being favorable.

6. Land previously grown to cogon can be used for planting yautias without any injury to the latter.

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A Series of Crop Rotations, with and without Legumes

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INTRODUCTION

Though experiments looking towards finding means by which the fertility of the soil could be maintained have been in progress for more than two-thirds of a century, no agricultural country has yet fully solved this problem. It is the object of this paper to review some of the work done towards solving this problem in other countries, and to describe the beginning that has been made at this college.

REVIEW OF THE PREVIOUS WORK ON THE SUBJECT

The experience of many generations of farmers in Europe and America has taught that tillage and fertilization are not the only means of maintaining the yield from a given soil, but this may also be accomplished by growing different crops one after another on the same field instead of growing the same kind year after year. These farmers have also found out that some crops will not grow well after others, that there are some that will grow very much better if planted only after a certain special crop. This is accounted for by the fact that some plants render the soil unfit for the growth of other plants, or harbor insect and other diseases that are injurious to the succeeding crops. This is principally true of plants closely related to each other. With plants not closely related to each other the opposite has been found to be true; as, for example, a legume crop followed by a grain crop or vice versa has always proved beneficial. Plants differ in manner of feeding and hardiness, that is, some can prosper where very little food has been placed at their immediate disposal, as spurrey, which is grown in Europe to be plowed under as green manure for rye. Carrot is another illustration. In England carrots are constantly grown without soil dressing of any kind, while turnips, which require less amount of food than the carrots, fail on the same kind of ground without a heavy dressing of manure. (3)

Certain plants are found to grow well on land previously occupied be legumes. This is especially true of crops which require a large amount of nitrogen in their growth. Leguminous plants, as has long been known, are able to obtain nitrogen from the air and fix it in the root tubercles. At the Michigan Experiment Station, it was found that soy bean, with tubercles on the roots, yielded 113.33 pounds of nitrogen per acre and only 75.98 pounds when without tubercles. Cowpeas with tubercles yielded 139.21 pounds of nitrogen and only 118.45 pounds without tubercles. (1) At this college, it has found that the following leguminous plants were able to fix the given amount of nitrogen from the air: (2)

	Name of Plants	*Kilos of Nitrogen per Ha.*
1.	Peanut—*Arachis hypogæa*	10
2.	Sincamas—*Pachyrrhyzus erosus*	140
3.	Cowpeas—*Vigna catjang*	70
4.	Sinay bean—*Phaseolus calcaratus*	70
5.	Ami's bean—*Glycine hispida*	20

Another effect of legume is the improvement of the physical condition of the soil. The plowing under of legumes makes sandy or gravelly soil darker and more retentive of moisture, and clayey soil more porous and friable and thus less subject to puddling or baking.

In England, Germany and other countries of northern Europe, systems of rotation seem to have originated directly from the customs prevailing in the village communities (3). When the

village and not the indidivudal had management of private affairs, it was a common practice to farm as a community, that is, several individuals worked in a common tract, but each has a strip assigned to him for a given season. When the field was large, it was usually divided into three sections, one part of which was devoted one year in three to winter grain, another part for summer grain, while the third part was left fallow. This was the origin of the "three-course" rotation which for many centuries was practiced almost universally in the more fertile parts of Europe.

The three-course system was greatly commended in those days of the village communities because of its regularity and simplicity and the possibility of cultivating land in a wholesale way at a small cost of supervision and labor. The abundance of land which could be used as pasture made it also possible to maintain the system for a long time. But as the population increased, the pastures were fast converted into arable lands and new systems had to be resorted to in order to provide food for the animals.

The first modification of the three-course system was the introduction of grass as a regular part of the rotation. It was first parcticed in moist countries which were especially fitted for grazing, such as Holstein and Mecklenburg. It was this practice which raised these countries to a high place among the agricultural and cattle producing regions. The same method was also employed in Scotland and in the midland countries of England, and the numerous enclosed fields and hedge-rows which are still found in certain parts of England are relics of the time when the three-course system was changed by the introduction of grass. The advantage of grass in the rotation was that it gave artificial pastures which were maintained for several years in alternation with grain. The system has proved successful wherever the climate permitted the grass to remain green throughout the year; consequently, each country has devised its own system, one that fits its purposes and conditions well. Some of the series derived from the three-course system are here quoted from Storer (pages 87-92): (3)

"There are many varieties of this system of grass rotation. Thus, in Holstein, one way is: 1, oats on the newly broken grass land; 2, fallow to destroy grass and weeds; 3, wheat with or without manure, according to the state of the land; 4, barley; 5, rye, lightly manured; 6, oats; 7 and 8, pasture. An old Scoth rotation was: 1, fallow; 2, wheat; 3, grass, fed for one, two or three years; 4, oats, peas or beans; 5, wheat, again. An old system employed in the midland countries of England was: 1, oats, on the sod; 2, wheat; 3, barley sown with the grass; 4, pastures for seven or eight years.

"In the United States several series have also been tried. A common series in western New York is: 1, Indian corn on sod with manure; 2, barley or oats; 3, wheat; 4, clover, mown for hay, and afterwards for seed; 5, clover and timothy, mown for hay. In Pennsylvania the older plan was: 1, maize, manure on the sod, which was plowed under in the spring; 2, oats, without any manure; 3, winter wheat and grass, usually dressed with 10 or 12 loads of barnyard manure. A more modern series is: 1, maize, manured; 2, part tobacco and part maize; manure is supplied in the second year as well as in the first and the tobacco often gets a dressing of superphosphate; 3, winter wheat, with timothy seed and clover sown in the next spring; not infrequently 200 to 300 lb. of superphosphate are applied to the wheat, and a part of the

land may be devoted to oats and potatoes in the third and fourth years; 5 and 6, clover and grass, mown for hay and subsequently pastured. Another course which has long been popular in the North of England and Scotland is: 1, wheat or oats; 2, turnips or other roots; 3, barley or oats; and 4 and 5, clover and grass. This series is termed the five-course rotation and sometimes it is changed to six by taking two grain crops in succession after the grass."

As may be deduced from the different series given above, the modern systems which originated from the old three-course rotation were adopted in order to get from the land, in a given time, as many merchantable products as can possibly be obtained by the judicious expenditure of labor and capital. In former days, the use of modern machinery was yet unknown, so care was always taken in apportioning the land so that the crops might be arranged in such order that labor was uniformly distributed throughout the year. It was very necessary for farmers in those days to know how many days of labor would be required and at what times, for putting in and taking care of each crop, in order that no one crop in the rotation should interfere with the proper treatment of others.

As labor plays a very important part in making farming a success, the farmers usually adjusted crops to labor rather than labor to crops. The area of the land that could be devoted to certain crops in a given time depended upon the number of men and work animals available at that time.

While it is to the farmers' advantage to get as many salable products as possible from a given piece of land in a given time, yet they did not lose sight of the cleansing effect of the crops upon the land. Certain crops, if grown in succession, or if insufficient time was allowed between the taking out of one crop and the putting in of the other, even if they were not alike, would render the soil foul and encourage the growth of weeds and insect pests. The application of some cleansing cultivation between the harvesting of one crop and the planting of its successor has always received careful consideration from those practicing crop rotation.

Just like any other business which follows certain rules in order to obtain successful results, rotation has also its rules. For this purpose it is well to quote Storer (3) on Minor Rules of Rotation which he has summarized from several writers on the subject:

1. "Such plants as tend to exhaust the soil, like the grain crops, should only be sown when the land is in good heart. They should not be made to succeed one another, but may be followed by plants that are less exhausting.

2. "In proportion as the soil is found to be easily exhausted by cropping, plants that are non-exhaustive should be grown more frequently from it.

3. "On heavily manured fields, stout plants should be sown as can bear the rankness of fresh manure; while other plants may follow them to good advantage.

4. "It is advantageous to alternate plants that have tap roots with those that have spreading roots.

5. "Some crops, like wheat, demand a firm footing, i. e. they grow best on soils that are tolerably compact; while other crops, such as turnip, for example, prefer a looser tilth.

6. "No two crops favorable to the growth of weeds should be permitted to succeed one another.

7. "As with weeds, so with insects and fungi. It is essential in many cases to change the crops frequently to hinder the increase of the pests."

With the use of commercial fertilizers in rotation, several other modifications have been developed but all adhere, more or less, to the foregoing general principles.

The oldest experiments on rotation for investigating the relation of crop yields to soil, were made at Rothamstead in England. This station was formally started in 1843, though some experiments had been going on at this point since 1837. The next experiment station of this kind was started nine years later at Mockern, Germany. Several years afterwards, the United States followed, headed by the Illinois Agricultural Experiment Station in 1879, then came the Pennsylvania State College in 1882, Minnesota in 1883 and Ohio in 1894 (4). In the Philippines, practices which approach crop rotation are common in Pangasinan, where rice is followed by mungo, (*Phaseolus mungo*). But even with this practice, no records have been made to show exactly to what extent a crop of rice is benefitted by growing mungo before it. What the farmers know is, that if they plant mungo after a rice crop the next crop of rice will be bigger, other things being equal.

In Europe and America systems of rotation are developed to suit local conditions. Here in the Philippines where conditions are very different from Europe and America, systems will have to be developed to suit our conditions. As the one in progress at this college is an initial work of this kind here in the Philippines, several series have to be started so as to cover a larger field. The object in view in conducting these several series is mainly to determine what systems are likely to prove profitable in this region. The results obtained may at the same time suggest a working plan that may be followed elsewhere in the Islands.

EXPERIMENTAL

Ten series were started. Five very important crops were used. The cowpea was included in the series in preference to other legumes as it has given good results in other countries and can be easily grown in the Philippines. This plant resembles our *paayap* or *sitao*. During the rainy season it vines heavily, but in the dry season it behaves like a bush bean. This plant, besides its value as green manure, can also serve as food. The green tender pods are eaten like paayap and the mature dry seeds are eaten like mungo. The use of commercial fertilizer and barnyard manure is excluded in this work for such are not readily available on Philippine farms.

The land used for this experiment is located on the northeastern corner of the college farm, across the Molauin Creek. According to local information, this land had been used exclusively for growing sugar cane, rice or corn. The land was thickly covered with wild grass and weeds when it was purchased by the college, for the owner had left it uncultivated since 1896. The college had harvested from it a crop of corn before this experiment began.

There are ten plots, each having an area of 1000 square meters. The plots are numbered 1, 2, 3, etc., as there are series. Each plot is treated as an independent field. The kind and the amount of labor were kept separately for each plot. The time of planting and of harvesting of every crop was recorded. The ease with which a plot was prepared for planting was carefully noted. Uniform treatment in the way of preparing the ground and in its cultivation was given careful attention so that if any differences occured in the yields, these may not be ascribed to the differences in soil preparation and cultivation. The series run as follows:

Plot 1. Corn and sugar cane.
Plot 2. Corn and cowpeas
Plot 3. Corn after corn.
Plot 4. Corn, cowpeas, rice and cowpeas.
Plot 5. Corn and camote.
Plot 6. Cowpeas after cowpeas.
Plot 7. Rice and corn.
Plot 8. Camote and cowpeas.
Plot 9. Camote after camote.
Plot 10. Sugar cane and cowpeas.

YIELDS PER HECTARE IN KILOS

		Plot I				Plot II				Plot III		Plot IV					
		Corn		Sugar Cane		Corn		Cowpea		Corn		Corn		Cowpea		Rice		Cowpea	
Crop	Date	Total Yield	Ears	Total Yield of Cane		Total Yield	Ears	Total Yield	Seed	Total Yield	Ears	Total Yield	Ears	Total Yield	Seed	Total Yield	Clean Seed	Total Yield	Seed
1st Wet season....	1915	17635	4204			16970	4136			17585	4147	17208	4122						
1st Dry season....	1915 and 1916			55470				1288	74	4740	2390			2305	123				
2nd Wet season....	1916					14765	3795			14050	3670					1289	45		
2nd Dry season....	1916 1917							2201	237.5	5061	2098							2495.8	258.8

		Plot V				Plot VI		Plot VII				Plot VIII				Plot IX		Plot X		
		Corn		Camote		Cowpea		Rice		Corn		Camote		Cowpea		Camote		Sugar Cane	Cowpea	
Crop	Date	Total Yield	Ears	Total Yield	Root	Total Yield	Seed	Total Yield	Ears	Total Yield	Ears	Total Yield	Root	Total Yield	Seed	Total Yield	Root	Yield of Cane	Total Yield	Seed
1st Wet season....	1915	17356	4131			13001	287	Rice destroyed				33100	5490			33790	5200	58810		
1st Dry season....	1915 1916			32.300	5160	10586	254.9			5420	1770					22780	6787			
2nd Wet season....	1916					10350	168.8	790						12040	268				11530	185
2nd Dry season....	1916 1917	7256	2972			20595	99.5			6440	2500	12451	5631			5323	1033			

In the preparation of the ground the first breaking of the soil was done with a big plow drawn by three bullocks. Immediately after plowing, while the ground was yet moist, it was disc-harrowed thoroughly so as to break most of the clods. It was then left for at least a week, oftentimes longer, then plowed again with a single-animal plow and then harrowed thoroughly until the ground was fine. In most cases after the last harrowing, the land was ready for planting. When a crop had large stubbles, such as sugar cane, more than two plowings were necessary to put the ground into shape.

Planting was all done by hand and a standard spacing was adopted for each crop. For corn, the spacing was 1 meter by 1 meter with two plants to a hill. For sugar cane, the spacing was also 1 meter by 1 meter with one cutting to a hill. For rice, the distance was 75 centimeters between the rows and approximately 10 centimeters between the hills. Camote was spaced 75 centimeters by 70 centimeters and cowpea 1 by 1 meter with three plants to a hill during rainy season and 1 meter by 75 centimeters during dry season. No rigid selection was made in securing seeds for the crops, but the best of the stock was always saved for the next crop.

Cultivation was all done by animal power. A five-toothed cultivator was the implement used. Once in a while some student laborers were employed for thinning and for pulling out weeds which the cultivator could not handle. Cultivation was resorted to whenever necessary. Like crops grown during the same season were given the same amount of cultivation.

In harvesting practically everything was weighed, excepting the straw in rice and the residues of sugar cane. Corn was harvested when the stalks were almost dry. Stalks and all were weighed and then the ears were husked and the clean ears weighed. The stalks and husk were piled for compost. The pods of the cowpeas were picked as fast as they got dry. During the rainy season three pickings removed most of the good pods leaving the vines still in good condition to be plowed under. In the dry-season crop, two pickings only were necessary. After the last picking the vines were cut close to the ground and weighed, then scattered again, disc-harrowed and plowed under. In harvesting rice, only the heads were removed, as in the native method of harvesting, and the straw was plowed under. In camote, roots and vines were weighed. The vines were piled for compost. Only the cane was weighed in sugar cane, the leaves and other residues were allowed to rot, then were plowed under. The stubbles when plowed out were piled for compost. The composted materials were returned to their respective plots when sufficiently rotted.

The first planting was made May 24, 1915, for all the plots, except plots 8, 9, and 10, which were to be planted with camote and sugar cane but no cuttings were available at that time. Plot 10 was planted with sugar cane June 3, 1915, and plots 8 and 9 were planted with camote July 30th. After this first planting, each crop was planted as soon as the plot intended for it was ready. There was not plan as to how many crops should be planted during any one year but the aim was to get as many crops as time and weather permitted. On account of the exceptionally long wet seasons during the last two years, only rainy and one dry-season crop were grown from each plot for each year. The planting then was divided into wet- and dry-season plantings and for the rest of the discussion "wet" and "dry" would distinguish one crop from the other.

From May 24, 1915, to March 14, 1917, the following crops were harvested with records:

Plot 1. One corn, one sugar cane.
Plot 2. Two corn, two legume.
Plot 3. Four corn.
Plot 4. One corn, two legume, one rice.
Plot 5. Two corn, one camote.
Plot 6. Four legume.
Plot 7. One rice, two corn.
Plot 8. Two camote, one legume.
Plot 9. Three camote.
Plot 10. One sugar cane, one legume.

The following table gives the computed yields per hectare of each of the crops grown in the different plantings. These figures were obtained by multiplying the actual weights obtained by 10, since each plot is one-tenth of a hectare.

The difference of 56 kilos of ear corn per hectare in the average yields of two years' cropping in favor of the field where corn and legume were planted in rotation, as compared with the field where corn was grown all the time, speaks of the advantage of one system of farming over the other. In every instance where a legume or a root crop has entered into the rotation, there is always a material increase in the yields of plots receiving such treatment. To make the table clearer a comparative discussion of the different series is hereby given.

PLOT 1.

This plot was intended to find the effect of corn on the yield of sugar cane. It is a common practice among the Filipino farmers to grow corn after a crop of sugar cane. As the results so far obtained do not warrant any comment on the system, since there was only one crop of corn and one crop of sugar cane planted, no discussion of the result is given here. However, judging from the effect of corn on the depletion of the soil in the other systems, it may be reasonably expected that in the long run corn will have the same effect on sugar cane, as it had on the other crops tried.

PLOT 2.

Plot 2, as may be noted, turned out two rainy-season crops of corn and two dry-season crops of legume, with an average of 3965.6 kilos of ear corn and an average yield of 1588.7 kilos of vines and 155.8 kilos of seed. The vines were turned under to benefit the following crop of corn. The average of 3965.5 kilos when compared with 3908.5 kilos the average of the two corn crops raised at the same time in Plot 3, gives a difference of 57.5 kilos in favor of Plot 2. These results tend to show that the depletion of soil is less rapid when cowpea is rotated with corn than when corn is planted year after year. Aside from preventing the rapid depletion of the soil for corn, rotating with legume produces another beneficial result and that is, the soil always remains in good tilth. Some farmers in the Philippines are aware of the good results of such a practice; but, so far as known, nobody adheres to it systematically with careful noting of results.

PLOT 3.

The yields of this plot clearly indicate the fallacy of this system of farming. As may be noted, there is a gradual decrease in the yields. When the yield per season is compared with the yields of the other plots producing corn at the same time, the yields of the other plots are comparatively higher. Plot 7, with a comparatively lower yield in its corn crop for the first day season corn crop, 1770 kilos as against 2390 kilos of Plot 3, shows better yield, 2500

kilos as compared with 2098 kilos of Plot 3, for the last corn crop. There is a difference of 402 kilos in favor of Plot 7.

It is not only the yield which is noticeable in this plot. This was harder to prepare than a plot in which a legume was planted. In this plot where corn was grown crop after crop, the clods were larger and harder to pulverize, than those in plots where cowpea vines was plowed under, where the soil was more easily prepared. There was also a considerable difference in the amount of weeds that grew in this plot, as compared with the others. As was mentioned above, all these plots were full of weeds during the early part of the experiment. In the other plots, the weeds were gotten under control after the second and third planting, but in this plot the weeds were still abundant up to the last planting, showing that the continuous planting of corn does not only deteriorate the soil but also harbors weeds.

Plot 4.

Plot 4 shows a more elaborate system of farming. The system corresponds somewhat to the "four-course" system in other countries. It was the aim in this sytem to find what would be the result of growing corn and rice when a crop of legume is to be grown between. As the system has gone through only one course, there is not much that can be said about it. The yield of 1289.5 kilos of hulled rice can however be compared with the yield of Plot 7. These two plots were planted at the same time and were given the same amount of care. The difference of 499.5 kilos in favor of Plot 3 can no doubt be credited to the crop of legume plowed under which benefitted the rice crop. Like Plot 2, this plot was also easier to prepare and the weeds were not as troublesome as in Plot 3.

Plot 5.

The planting of a hoed crop and a grain crop has always been commended in Europe and America for the reason that a hoed crop makes a good preparator crop for a crop of grain. The reason for this is that the plowing out of the roots brings a greater amount of soil directly in contact with the atmosphere, thus favoring the chemical and biological changes in the soil that tend to increase the available food for the plants. Another explanation for this is that a grain crop and a hoed crop differ in many respects as to mode of growth and nature of feeding and the secretion of the roots of one is not injurious to the roots of the other, thus enabling one crop a good opportunity for growth and production.

The growing of corn and camote in succession in this plot gave results similar to those obtained in other countries where corn and similar root crop have been grown in rotation. The results obtained here show that the field would yield a fair quantity of roots and the crop of corn following it would be considerably greater than where corn alone, or rice in rotation with corn is grown. In Plots 3, 5 and 7, the dry-season corn crops were planted at the same time and the crops were harvested March, 1917. Plot 5 is 872 kilos ahead of Plot 3, where corn was grown crop after crop, and 432 kilos ahead of Plot 7, where rice and corn were grown in succession.

Plot 6.

The fallacy of growing the same crop one after another is even more greatly emphasized in the case of Plot 6. This plot was planted to cowpea from the start and there were four harvests made; two wet-season crops and two dry-season crops. As the cowpea can obtain nitrogen from the air

and thus can enrich the soil in this element, one might conclude that by growing a legume year after year and turning under the vines each time, there should not be any decrease in the yield of seeds. But the results obtained show that such is not the case. Instead, there is a gradual decrease. For the second wet-season crops of 1916, Plots 8 and 10 showed even better results than Plot 6, when in Plot 8 the cowpea followed a crop of camote and in Plot 10 a crop of sugar cane. Both camote and sugar cane are exhausting crops but there appear differences in the yields of 99.2 kilos of seed and 1690 kilos of vines and 17 kilos of seed and 1180 kilos of vines in favor of Plots 8 and 10, respectively.

The decrease in yields of this plot was to a great extent caused by weeds, disease and pests. A crop of cowpeas, even if it produces a heavy foliage which practically covers the ground, still allows one kind of grass to grow. This grass seems to thrive even if completely shaded by the vines. Another and still more noticeable thing in this plot was the great susceptibility of the plants to the attacks of insects. During the last two seasons, the root-maggot and the aphids were exceptionally abundant. During this time, there was always a much larger number of plants in Plot 6 that were damaged by the insects than in any other cowpea fields.

PLOT 7.

Plot 7 has for its series rice and corn, two grain crops that are highly exhausting. This system is one which is universally practiced by the farmers in the Islands. Our native farmers believe that it is good farming when they can get a second crop, such as corn after a crop of rice, before the hottest part of the dry season. Since they are contented with what little yield they get from either crop, they never try to determine whether the practice is profitable or not in the long run. The only thing that they know is that after several years they have depleted their lands to such an extent that they find that growing crops on them does no longer pay. Then they give these fields a long rest. They fail to see that their system of farming is entirely responsible for the refusal of the land to give them a paying crop.

This plot brought about results similar to what the native farmers have accomplished in the way of reducing their yields. The 1915 rice crop of Plot 7 was destroyed by a *baguio*. It was a good crop and was within only a few days of harvesting when a big *baguio* flattened the plants and very heavy rains rotted everything. As nothing was removed from the soil, it was expected that the corn crop which followed this rice crop would give as good a crop, or even better, than the other plots where a certain amount of the fertility of the soil had been removed by the previous crops. But the average of the two dry-season crops of ear corn, 2135 kilos as against 2244 kilos of Plot 3 shows that the system is just as bad, if not worse, than where corn was grown all the time. However, when the total yield of the two dry-season corn crops of 9801 kilos of Plot 3 is compared with the total yield of the two corresponding season crops of Plot 7, 11860 kilos, there is a difference of 1959 kilos in favor of Plot 7. But since it is the marketable portion of the crop that counts, the growing of rice and corn is therefore not as beneficial as when corn is grown crop after crop.

The rice crop of Plot 4 is greater by 499.5 kilos than that of Plot 7. These two crops were planted and harvested at about the same time. This result tends to show that just as in the case

of corn, cowpea prevents the rapid depletion of the soil for rice. A plot intended to serve as control for rice was begun after the first year and no data are yet available from it. The effect of corn on rice can not therefore be discussed. According to the results of Plot 7, rotation with rice would be more beneficial to corn than the continuous planting of corn crop after crop.

Plot 8.

The first crop of camote was planted July 30, 1915, and harvested February 10, 1916, thus occupying the ground for a little more than seven months. The crop of cowpea was planted May 27, 1916, and plowed under the first week of September of the same year. On account of the exceptionally long wet weather, no planting could be made until about the middle of November, so the soil for this plot was left fallow for at least two months. The second crop of camote was planted November 18, 1916, and harvested March 14, 1917, approximately four months after planting. Were it not for the lack of time the crop would have been allowed to remain longer. The third crop of Plot 9 which was intended to check the second crop of Plot 8 was treated in exactly the same way.

Comparing the result of Plot 8 with that of Plot 9, the good effect of rotating with cowpea is again observed. The last camote crop of Plot 8 gave 12451 kilos of total yield and 5631 kilos of roots. The corresponding crop of Plot 9 produced 5323 kilos of total yield and 1032 kilos of roots. There is therefore a difference of 7128 kilos in the total and 4594 kilos in the roots in favor of Plot 8.

This good effect of cowpea on camote is to be ascribed, not only to the increased nitrogen content of the soil, but also to the improvement of the physical condition of the latter by the presence of the vines which were plowed under and rotted. Aside from the effect on the physical condition, the plowing under of the vines also increased the available plant food in the soil. The improvement of the physical condition of the soil is very striking if Plot 8 is again compared with Plot 9. When working up both plots preparatory to planting the last camote crop, it was noticed that the clods in Plot 9 were larger and harder to pulverize than those in Plot 8, so that much more labor was spent in its preparation. When the dry spell of about two weeks ensued, the plants in Plot 8 stood the drought much better than those in Plot 9. It is therefore evident that rotating camote with cowpea not only prevents the rapid exhaustion of the soil but also saves the crop from the effect of drought. Since long spells of dry weather are common in many parts of the Philippines, these results are of high practical value.

Plot 9.

This plot was intended to check Plot 8. The first crop of camote was planted and harvested at the same time as the first crop of Plot 8. The yield as may be noted, is 690 kilos greater in the total yield and 290 kilos less in the roots. The second crop was planted during the first week of May and was harvested November 30. The total yield was smaller than the previous yield by 5010 kilos, but the yield in roots is greater by 1587 kilos. It is interesting to note the sudden drop in yield from the second to the third crop. As indicated in discussing Plot 8, this drop was to large a extent due to the effect of drought.

Plot 10.

This plot was intended to check Plot 1. Here cowpea was rotated with

sugar cane instead of corn. Since the data on hand are not sufficient, no discussion can be given here. However, judging from the effect of cowpea on the other plots, rotating sugar cane with legume would no doubt prevent the rapid decrease in the yield of sugar cane which takes place when sugar cane is cropped year after year.

A study of the foregoing table discloses the fact that the total weight of ear crop, when corn is planted year after year, exceeds the total yield of ear crop when corn is rotated with cowpea. The same is true of the total weight of the camote obtained when camote is planted year after year as compared with the total obtained when cowpea is rotated with camote. These results show that a yearly rotation of corn and camote would not be profitable within the first three or four years. Whether it would be profitable after that, is still an open question. Work on this same problem is proceeding right along.

SUMMARY

1. Continuous growing of one crop on the same field causes rapid depletion of the soil and encourages the development of weeds and insect pests.

2. When a legume is used in rotation with other crop and the vines are plowed under, two beneficial effects are obtained. The physical condition of the soil is improved and its rapid depletion is prevented.

3. The growing of root crop after a crop of corn also prevents the rapid depletion of the soil for corn.

RECOMMENDATIONS

1. It is earnestly recommended that rotation be practiced especially in large-scale farming.

2. Grow legume in soil deficient in nitrogen.

3. The question of maintenance of soil fertility being a national issue, it is urgently recommended that the government provide means for carrying on investigations of this kind in the different parts of the Islands, so as to save our soil from rapid depletion.

4. Any individual or private concern can also lend a helping hand in the solution of this problem by conducting investigations along this line.

ACKNOWLEDGMENTS

I desire to express my obligation to Professor Charles Fuller Baker for valuable suggestions and criticisms during the course of this experiment. I also express my thanks to the other members of the Agronomy Department who have made it possible to secure the necessary labor to carry on the investigations.

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A Preliminary Study of the Philippine Coconut-Oil Industry

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Thesis presented for graduation from the College of Agriculture, No.68.

INTRODUCTION

The increasing demand for coconut oil makes the Philippine oil industry a subject of sufficient importance to warrant its investigation with special emphasis on the efficiency of the native oil-press methods. The work to be described is a study of the factory conditions in some oil-producing localities in the province of Laguna. The methods of oil extraction in this province are very similar to those used in the coconut regions of Tayabas and Camarines so that the results of the present work are also applicable there.

DESCRIPTION OF THE NATIVE METHODS

in use: (1) the "hand-press" and (2) the "machine-press" methods. The hand press method involves no special apparatus and consists merely of macerating the endosperm and in squeezing out by hand as much of the milk as possible. The milk generally contains 50% to 60% oil and is boiled in open pans till the water evaporates. Oil produced in this way is generally of good quality and is commonly used for domestic purposes. The yield, however, is low.

In the machine-press method the husk is removed and the nuts are broken into halves; the meat is grated from the halves by a native machine, *kabyawan*, which has small rotary knives; the grated meat is then cooked with water in shallow iron pots. The resulting white mash is then put into rattan bags and pressed in a vertical press, *hapitan*. The juice squeezed out falls directly into a large wooden trough. This liquid is then boiled to obtain the oil by evaporating the water. The first pressed oil is of superior quality and is used for culinary purposes. After expression, the cake is allowed to stand till fermentation begins; it is then ground by means of wooden, stone, or cement grinders, called *ilohan*. The cake is ground and pressed over again, usually six or more times, until all the oil is squeezed out. The oil obtained from the last expression is of inferior quality and is used for illumination and soap manufacture.

In the factories visited the following native appliances make up the outfit:

The husker is a sharp iron bar set firmly into the ground or fastened in a block. It stands point upward, a little higher than the worker's knee. With this device an expert workman can husk 1000 to 2000 nuts daily, receiving ₱0.50 to ₱1.00 per thousand. The wages for husking, however, depend upon the market price of oil and copra.

The scraper, *kabyawan*, Plate I, Figure 1, is a convex iron burr mounted on the end of an axle; a cord is wound several times and the two ends fastened to pedals. The surface of the burr is serrated, and, when revolving, scrapes out the meat of the half-nut which is pressed over it. In using this machine the operator sits in such a position that this feet press the pedals down alternately thus revolving the axle and burr. The burr points away from the operator, so that when he takes a half-nut in his hands and presses it against the burr, he can watch the removal of the meat. The apparatus is very effective, as in less than 30 seconds the meat is removed

from the half-nut. Due to the large teeth of the burr, the meat is very coarsely grated; but in spite of this fault it is the scraping machine in use in all the factories visited. In Factory No. 9 an improved machine of American make is under test. An illustration of the latter machine is shown in Plate I, Figure 2. It is built on somewhat the same principle as the *kabyawan*. Three men are used to run it, instead of one, as in the native machine. One man draws the half-nut against the burr and the two others rock the motor wheel which is fitted to the axle of the burr. back and forth. The grated meat turned out by this machine is very fine because of the small teeth on the burr. Both machines require three men and one day to scrape 1000 nuts. The advantage claimed for the improved machine is that by its use 25 gallons of oil are produced from 1000 nuts against 20 gallons when the native machine is used. An operator is paid ₱1.00 to ₱1.50 per 1000 nuts.

In all factories studied, except Nos. 2 and 9, the furnace on which the coconut is cooked and the milk boiled is constructed of ashes and mud plastered together. It has the shape of a hollow cone with an open top and with openings on opposite sides. The caldron containing the meat or milk is placed over the top opening, and the side openings are used to put in the fuel and take the ashes out. Coconut husks and shells are used for fuel. The furnace furnishes heat enough to convert about 50 gallons of coconut milk into superior oil in about three hours. The objections to this type of furnace are that a great deal of heat is lost, and it has no chimney, so the smoke blackens the interior of the building (Plate II, Figure 1). Factories described as Nos. 2 and 9 refer so the same factory visited at different times while it was under the management of different men. This factory is provided with a simple furnace which is more satisfactory than the one described above. The furnace is a rectangular box and is constructed wholly of stones and mortar. At one end it has an opening of convenient size for putting fuel through and taking ashes out. A chimney is attached to the opposite end. On the top of the furnace are two depressions in which the convex bottom of the caldrons fit snugly. This particular factory is characterized by being exceptionally clean, and the secret to this condition lies in the construction of its furnace.

The caldrons are similar to boiling pans used locally in boiling sugar. Considerable time is spent in watching these open caldrons during the boiling process to prevent the mash of the milk from boiling over. Time and labor might be saved by using caldrons with higher sides similar to those used in soap factories.

The native coconut-oil press is made of two large boards and one or two wooden screws usually about 10 centimeters in diameter. One end of the screw is fastenend to the wall, the other end passes through the two boards of the press into a threaded block. By turning this block great pressure can be applied to the front board. Such an oil press is shown in Plate III, Figure 1. It is evident that a press with two screws is more efficient than one having only one screw. A press of the two-screw type can press three bags of coconut meat at one time (one bag at each and one in the middle of the press), Plate III, Figure 2, while a press of the single-screw type can press only one bag of meat at a time. The oil manufacturers met by the writer in the field do not seem to realize the advantage of the double-screw press over that of the single-screw type. The users of the single screw press stated that they could express as much oil as those using the double-screw press; they disregard altogether the time saved by using the latter. The writer was surprised to find that nine out of eleven factories visited were using the single-screw press. One special form of bag is adapted for holding the coconut meat while being pressed in the *hapitan*. It is made of rattan woven after the fashion of *sawale*. (1)

1 Sawale is a durable native mat, woven from bamboo strips. It is extensively used in the Islands as interior partitions and ceilings of houses.

It has an open top and tapering bottom, as is shown in Plate I, Figure 2, and generally comes in size about 40 centimeters wide and 60 centimeters long. Such bags answer the purpose well and no satisfactory substitute for them has yet been found.

The grinders of all the factories studied, except No. 2, are made of either wood or stone. Each is composed of heavy rollers rocking backward and forward on supports which are notched to fit the bearing ends of the roller. The meat is crushed between the support and the roller, and ground by rocking the heavy roller. A photograph of the apparatus is shown in Plate II, Figure 2. If the roller of the grinder is made of wood and is rather light, much grinding is required to crush the meat; but if made of stone, it is heavier and it is hard work to produce the rocking motion desired.

In all the eleven factories studied, except No. 2, the trough used is a crudely hollowed-out log, as shown in Plate III, Figure 3. Usually the trough has a diameter of about 25 centimeters and a length of about 1.5 meters. This wooden trough answers the purpose but can hardly be called satisfactory, for it is often porous and so absorbs much oil, and if it happens to have "heart-shake" cracks, oil is lost be leaking. In Factory No. 2 a trough made of pieces of galvanized iron, securely soldered together, is used. It measures about 2.5 meters in length or as long as the press and has a diameter of 30 centimeters at top and bottom. Its general shape is shown in Plate III, Figure 4. As a part of the oil factory outfit, it is very satisfactory, as it neither absorbs oil nor permits leakage.

Regarding receptacles or vessels for storing oil, "standard oil", cans, cylindrical tanks, and jars are employed The use of the oil cans and cylindrica tanks should be encouraged, for they are not porous and can be sealed airtight. The keeping of oil in earthen jars, *tapayan*, should be discontinued. Such receptacles are porous and allow oil to percolate through, are not easily sealed, and are difficult to move about, as they are heavy and fragile.

TABLE III

I	II			III			IV			V			VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Factory No.	Meat of Nuts as Used by Factories			Meal Scraped by Kabyawan			Boiled Meal			Last Pressed Meal			Weight of Oil per 1000 Nuts			Percentage of Total Oil Removed	Calculated Weight of Oil Removed Kg.	Calculated Efficiency %	Reported Weight of Oil Recovered	Reported Efficiency %	Difference between calculated and reported Efficiency %
	(a) H_2O %	OIL (b1) Wet Basis	(b2) Dry Basis	(a) H_2O %	OIL (b1) Wet Basis	(b2) Dry Basis	(a) H_2O %	OIL (b1) Wet Basis	(b2) Dry Basis	(a) H_2O %	OIL (b1) Wet Basis	(b2) Dry Basis	In meal Kg.	In Cake Kg.	Removed Kg.						
1	51.0	26.5	53.8	50.0	25.5	50.8	56.2	22.6	50.7	46.3	10.4	19.1	94.4	6.8	87.6	92.8	56.9	60.3	87.0	92.2	+ 31.9
2	50.0	25.9	51.0	47.8	25.0	48.8	53.5	23.1	48.1	42.9	8.5	15.1	91.3	5.7	85.6	93.8	65.2	71.4	95.7	104.8	+ 33.4
3	62.3	19.4	51.0	53.2	22.9	49.1	56.2	21.4	48.4	43.3	12.5	21.6	68.9	8.1	60.8	88.2	36.2	52.5	22.6	32.8	— 19.7
4	63.3	14.6	40.1	—	—	—	69.7	11.7	39.0	44.5	12.2	22.2	52.7	8.2	44.5	84.4	21.8	41.4	78.3	148.6	+107.2
5	61.3	22.6	57.8	62.0	20.6	55.3	—	—	—	33.2	4.4	6.5	80.0	2.7	77.3	96.6	49.4	61.8	95.7	119.6	++ 57.8
6	44.0	28.8	51.5	—	—	—	—	—	—	39.1	12.5	20.6	102.2	8.3	93.9	91.9	70.9	69.4	83.5	81.7	++ 12.3
7	53.4	35.6	64.6	52.5	30.4	63.1	—	—	—	40.7	5.6	9.5	107.7	3.7	104.0	96.6	81.0	75.2	57.4	53.3	— 21.9
8	50.1	31.8	63.2	47.1	32.0	61.9	56.1	27.1	60.8	44.5	18.2	30.8	112.9	11.3	101.6	90.5	77.7	68.8	69.6	61.6	— 7.2
9	44.5	30.0	53.5	—	—	—	—	—	—	47.7	10.9	20.5	106.3	7.1	99.2	93.3	76.2	71.7	69.6	65.5	— 6.2
10	40.6	37.1	61.9	—	—	—	—	—	—	54.6	23.7	52.4	131.6	15.7	115.9	88.1	92.9	70.6	74.8	56.8	— 13.8
11	42.5	36.0	60.1	—	—	—	—	—	—	28.1	3.4	46.1	123.7	17.3	106.4	86.0	83.4	67.4	92.2	74.5	— 7.1
12	45.3	24.5	44.3	40.6	26.3	43.9	—	—	—	31.1	3.8	5.5	86.8	2.5	84.3	97.1	65.3	75.2	92.2	111.9	+ 36.7

EFFICIENCY OF ELEVEN NATIVE FACTORIES BASED ON FIELD INVESTIGATION

To study the efficiency of native methods, field investigation was made. The aim of this part of the work was to compare the various methods and appliances actually in use by coconut-oil manufacturers, to collect data by actual observation during the visit and to secure samples for laboratory extraction. Information that could not be obtained while the factories were at work was given from memory by factory owners or manufacturers.

Most of the investigation was conducted around Lilio, Magdalena and Mojon, as in 1915 most of the factories in other parts of La Laguna were not in operation.

In the factories studied, notwithstanding the similarity of methods, appliances, and practices, considerable variation in results was discovered, as shown in Table II.

A study of Column V reveals that in Factory No. 1 the laborers attended to all the work involved in oil making and the owners are relieved from care. In Factories Nos. 2 and 9 both the owners appear to have a "square deal" with their laborers. In the practice followed by Nos. 3, 6, 10, 11 and 12 the laborers are underpaid. Their wages range from ₱0.21 to ₱0.25 per can oil. This includes the labor of all processes from husking to the last expression, two men being the least number of men employed to work on 1000 nuts. The system employed by Factories Nos. 4 and 5 is based upon cooperation between the owners and laborers. If the latter are honest and know how to buy the nuts at the proper price, and sell the produce to advantage, both parties make a profit. Evidently Factories Nos. 7 and 8 pay too much for labor. By this particular method, laborers receive ₱5.00 to ₱5.50 per 1000 nuts worked, no matter whether the owners gain or lose. From husking to the last expression of a given number of nuts, the laborers themselves decide upon the amount of help for the complete work (since they are paid for the job performed and not for the time spent). In this connection it is a general practice for friends to work together, or for members of the family to share in the work.

The figures in Column VI represent the highest number of nuts that a factory is capable of working on at one time. These figures depend mostly on the number and kind of presses employed, a thousand nuts requiring from 15 to 60 minutes to go once through a double-screw press, or three times as long if the single-screw press is used.

Column VII gives the average time it takes to extract the oil from a thousand nuts. The length of time depends largely upon the kind of press employed single-screw or double-screw, and the fineness of the grinding. Since the method partly depends on the chemical action which takes place in the coconut meat, softening it and thus materially aiding the grinding and pressing, the oil expression can hardly be finished in less than five days. Apparently the climatic conditions and the physical nature of the nuts are the controlling agents hastening or delaying the decomposition of the meat. In a modern oil factory, very much shorter time is needed to treat the same amount of meat, for recourse is not had to chemical agencies, the operators depending entirely upon the mechanical force of their appliances. A modern desintegrator, for instance, is capable of treating 227 to 2,045 kilos (500 to 4,500 lb.) of copra per hour according to the size of the machine.

In Column VIII are given the amounts of oil obtained from 1000 nuts. The

figures show considerable variation running from 3.25 to 5.5 cans. The probable explanation of this variation is the difference of the size of the nuts and in the degree of ripeness when they are opened.

A careful study of Columns VIII and IX reveals that the amount of cake in a given nut increases more or less regularly with the oil content. This observation agrees with Walker's figures for oil and copra content in nuts of varying degrees of ripeness.

The columns "Proceeds" and "Costs" represent the income from the factory products and the cost of the nuts, plus cost of production of the oil, respectively. The totals under the heading "Gain or Loss" is a summary, showing the standing of each factory. The net profits run from ₱0.12 to ₱9.51, a considerable variation, which may be chiefly attributed to the business ability of the factory owners or managers. Probably the most important factors determining the profits from oil manufacture are understanding how to select nuts as to their oil-yielding qualities and knowing what to pay for them. For example, as shown in the table, Nos. 2 and 9 represent the same factory but No. 9 under Mr. Luciano Pugian makes a gain of only ₱0.12 against ₱5.18 when under the care of Mr. Pedro Creido. Another striking difference in profits is exhibited in factories Nos. 11 and 12, ₱0.57 against ₱9.51. This should not be the case, for the factories are scarcely 150 meters apart and their owners are brother and sister. Apparently the brother is not so good in business as his sister, for he pays an average of ₱22.50 per 1000 nuts, while she secures a similar kind of nuts at an average cost of ₱14.50 per 1000. Considering the time required to manufacture oil from a thousand nuts, Nos. 2, 6, and 12 can be regarded as the most efficient for each of them gains about ₱1.00 per day on the capital invested per 1000 nuts. As a business-paying proposition, all the factorios studied, except Nos. 2 and 12 should go out of business, for their earnings scarcely pay for the running of the factories. In fact, Nos. 3 and 7 lose ₱7.83 and ₱2.58 per 1000 nuts, respectively.

The figures for costs and receipts furnished to the writer are only approximate, as no records were available in the factories examined.

EFFICIENCY OF THE NATIVE METHODS OF EXTRACTION, EXPERIMENTAL DATA

After studying the methods practiced and the appliances employed, the next problem for consideration in estimating the efficiency of the native method was the percentage of extraction made in the different factories.

To determine this in the coconut products available used in the manufacture of oil, the samples obtained during the field investigation were analyzed at the College of Agriculture, Los Baños. The analytical methods used are in brief, as follows.

(*1*) *Moisture Determination.*

The ground samples of about 5 grams each were weighed to the nearest decigram into tared aluminum pans. The pans with the samples were dried in the oven (water bath) at 1000 C. for about 5 hours. They were then cooled in dessicators for about 20 minutes, weighed and put back in the oven for about 3 hours. Heating, cooling and weighing were continued till the samples ceased to lose weight. The loss in weight was calculated as moisture. To prevent the oil from adhering to the pan and to assist in grinding the dried coconut meat for extraction, a small quantity of sand purified by washing with hydrocloric acid and water and

igniting to whiteness was weighed with each pan before the sample was put in.

Moisture determination was made in order to be able to report the percentage of oil in the dry basis.

(*2*) *Oil Extraction.*

Oil was extracted with the chloroform from the residue from the moisture determination, in an apparatus of local construction, designed to extract from 28 samples at one time (See Plate III, Figure 5). The apparatus is so arragend that hot condensed choloform falls continually on the sample, passes through it, and collects in the bottom of the apparatus where it again distills. After extraction and drying the oil is determined by loss in weight. The method was checked by the Soxhlet extractor and found to be of equal reliability. The percentage of oil found in the various products are given in Table III.

Column I, Table III, indicates the order of the factories from which the samples were obtained. All the figures in Columns II to VII, inclusive are averages. Columns II to V, inclusive, show the kinds of coconut products analyzed. In Column VI, the weight of oil per 1000 nuts for each factory is given. Figures in Column VII, represent the weight of oil as found in cake from 1000 nuts for each factory. Column VIII is the calculated weight of oil recovered per 1000 nuts. Column IX denoted the apparent percentage of efficiency based on the amount of oil calculated per 1000 nuts.

II. The expression "Meat of Nuts as Used by Factories" means the fresh coconut meat separated from the shell with the bolo. The sample was chopped fine and dried, the percentage of moisture obtained being shown in the subcolumn "b*1*" and "b*2*" calculated on the wet and dry samples, respectively. The object of analyzing this particular sample was to determine the total percentage of water and oil in the meat of a coconut. Samples of a similar nature were produced from the twelve factories and subjected to the same treatment. Referring to Table III, it is seen that the total percentage of oil in the meat of a coconut varies from 40.1% to 64.6%. Such variation was chiefly attributed to the different stages of maturity of the nuts when opened.

III. "Meat Scraped by Kabyawan" means the coconut meat grated by the native grating machine already described. The samples were treated in a manner similar to those for II. Samples of this kind of meat were not procurable from all the twelve factories at the time visits were made, for not all worked at the same time, nor did they keep such samples in stock. From Table III, it will be seen that in scraping operation only a slight percentage of moisture is lost due to whirling and exposure, but about 1.6% to 10.3% of the total oil is wasted due to adhering to surface touched by the meat.

IV. "Boiled Meat" is the coconut meat taken from the cooking caldrons. The samples were analyzed for moisture and oil. Referring to Table III, it will be seen that the cooking process increases the moisture in the sample to from 3.3% to 6.4%; this is not desirable. In the same process the percentage of the total oil decreases, about 0.4% to 3.5% of the decrease being probably due to volatilization.

V. "Last Pressed Meat" is the coconut cake as it leaves the factory ready to be fed to hogs. A study of this column together with Column II, Table III will show the wastefulness of the native oil press method as 5.5% to 52.4% of oil or 2.9% to 13.9% of the total oil is left in the cake, and sold at cake price rather than oil price. This means a great loss to the factory owners

and others concerned. Referring to Table II, "Efficiency of Eleven Factories Based on Field Investigation", it is evident that it is not the kind of press that determines the highest or lowest extraction since the two extremes 84.4% and 97.1% are both found in the factories using the single screw press. Apparently by the native method physical condition of the coconut meat and the extent of chemical action upon it are the chief agents governing the increase or decrease of oil production.

VI. "Weight of Oil per 1000 Nuts in Meat" gives the total weight of oil in raw meat per 1000 nuts for each factory. This is obtained by using 358, the average weight of raw meat per 1000 nuts (from actual determination of 30 nuts from 3 lots) as the base and multiplying it by the figures in the subcolumn "b*1*", Column II, Table III, the percentage of oil, in the wet samples.

VII. "Weight of Oil per 1000 nuts in Cake" indicates the total weight of oil in the cake per 1000 nuts for each factory. The weights in this column are found by using 66.2 kilos, the native average weight in 1000 nuts (from actual determination) as the base and multiplying it by the rates of percentage of oil, that are given in the subcolumn "b*1*", Column V, Table III.

VIII. "Weight of Oil per 1000 Nuts Removed" is the amount of oil removed per 1000 nuts at each factory. These weights are the differences between Columns VI and VII, Table III. They vary sufficiently to render puzzling any conclusions arrived at from analytical data. But taking into account the average make-up of the single-screw press and the methods followed (which are indentical in all the eleven factories), and the different degrees of ripeness when the nuts were opened, one may infer that the latter causes the variation.

IX. "Percentage of Total Oil Removed" shows the actual percentage of oil removed in each factory. The percentage of extraction is obtained by dividing the figures in Column VIII, Table III, by those in Column VI of the same table and multiplying the quotients by 100.

X. "Calculated Weight of Oil Recovered" is found by subtracting from VI the sum of VII, Table III, plus the loss of oil in scraping, boiling, grinding and in the *latic*.

XI. "Calculated Efficiency" is expressed in percentage, and is the result obtained by dividing X by VI, Table III and the quotients multiplied by 100.

XII. "Reported Weight of Oil Recovered" is a tabulation of the reports of the eleven factory owners or managers on the amount of oil in kilograms that they could extract from 1000 nuts. The figures were obtained by multiplying those in the column "Weight of Oil per 1000 Nuts in Meat", expressed in standard oil cans, 5 gallons, by the factor 17.4 which is the average net weight of coconut oil per can. As might be expected, the corresponding figures of Columns VIII and XII do not agree; those of factory No. 1 being the only ones that come close together. The figures for Factories Nos. 2, 4, 5, and 12 in Column XII are too high; and the rest are too low. These differences might be due to any of the following conditions: First, the samples may not have been representative of the year's run. Second, losses which occur by piling the meat on the ground and by the leakage already mentioned through the trough and other sort of apparatus would bring reported recovery less than the total extraction. And third, the report may be wrong either from the desire, for advertising purposes, of the factory owners to overestimate their results or from the lack of accurate knowledge owing to absence of book-

keeping in any form. The latter view seems to be the more probable one.

XIII. "Reported Efficiency" indicates the actual percentage of the oil recovered from 1000 nuts according to the report of the factories. Figures in Column XIII should agree with those of Column IX, but they differ for the same reasons as those in Columns VIII and XII. Notwithstanding these discrepancies the reports are far from useless for they furnish to the student a problem to solve; i. e., to ascertain the accuracy of such reports, they should induce the manufacturers to keep proper accounts of their business.

XIV. "Difference between Calculated and Reported Efficiency" is the contrast between Columns XI and XIII. Positive and negative quantities show whether the reported efficiency is above or below the calcaulated efficiency. Evidently the reported efficiency is erroneous for it even goes above 100%.

In the native method of oil manufacture, *latic*, the solid matter resulting from the conversion of the coconut milk into sweet oil by boiling, should not be considered as a trifle, as it contains a considerable amount of oil which may be recovered if treated in a manner similar to the treatment of the coconut meat. The oil is, as a general practice, drained off and the residue thrown away or moulded into a sort of "sealing cakes" to cover jars of oil. According to experimental data from samples secured, latic contains a high percentage of oil, ranging from 13.1% to 200% of the weight of the latic. Multiplying this rate percent by 33.3, the average weight of the latic per 1000 nuts, gives from 4.3 kilos to 6.7 kilos, the amount of oil per 1000 nuts wasted by the native methods. It is worth saving if only for stock feed.

NATIVE METHODS OF COCONUT OIL EXTRACTION COMPARED WITH THE MODERN METHODS

Though not primitive, the native method of extracting coconut oil already described is comparatively slow, as the extraction of from 1000 to 12,000 nuts requires from 5 to 8.5 days. As they have to wait for the chemical actions to take place in the coconut meat, the laborers are not at all times occupied.

Referring to Table III under "Experimental Data", it is seen that the efficiency of the native method ranges from 41.4% to 75.2% and averages 65.5%.

The method used in modern coconut-oil factories is much quicker and many times more efficient than the one just discussed. The general description of it which follows is taken from *The Coconut Palm and Its Products* by Thomas Barraclough.

In the modern coconut oil factories the hydraulic press, Plate III, Figure 6, is used and only two pressings are necessary in place of six or more, as required by the native press. The first pressing extracts from copra in its natural state the best quality of oil. Tha cakes are about 35 centimeters wide and 75 centimeters long and number from 16 to 18 pressing. The hydraulic press used for first pressing has a ram of 30 centimeters (about 12 inches) in diameter, and is capable of working to maximum pressure of 59 kilos (about 1 ton) per square centimeters.

For the second pressing the hydraulic presses have a ram of 37 to 38 centimeters (18.5 to 19.0 inches) in diameter and are capable of working up to 1,360 kilos (1.5 tons) pressure per square centimeters, or a gross pressure of 727, 200 to 772,650 kilos (800 to 850 tons.) This pressure is necessary to insure the

extraction of the maximum quantity of oil and also to insure the production of cakes of sufficient hardness.

For sun-dried copra containing dirt and variety of other extraneous matter, a magnetic separator is installed for taking out the bits of iron, nails, etc.

If the copra used is other than sun-dried and is free from extraneous matter, the first preparing machine is the disintegrator, a machine largely employed in modern oil factories. In the disintegrating chamber of the machine the copra falls on the extremities of bitters attached to a disc that revolves at a great speed. By this device desintegration is quickly effected. After disintegration, the copra next undergoes a fine grinding process with the object of preparing it further for the press. Finely ground copra meal, when under pressure produces a fine flow of oil and leaves cakes of equal density.

After being ground the meal is fed into a kettle furnished into a stirring apparatus for measuring the meal into quantities sufficient to form one cake. The meal is then subjected to slight preliminary molding in a compressing machine to which the kettle is attached, the object being to form and prepare the cakes for their first pressing.

After having been once pressed to the extent desired, they are removed, broken up, reground and then again pressed.

The breaking and regrinding is effected by passing the cakes into a special cake-breaking and grinding machine that reduces them in one operation to a fine meal. Such a machine is very powerful and effective and is capable of treating from 909 to 5,454 kilos (1 to 6 tons) of copra cake per hour, according to the size of the machine. After passing through this machine the fine meal is then fed into a kettle similar to the one already described, but with the addition of a steam-spraying apparatus by which necessary moisture is added and the meal heated to a temperature of about 180°F. The heat renders the extraction of the maximum amount of oil possible; and the moisture causes the particles of the meal to adhere with sufficient tenacity to form a cake. The meal then passes directly to a molding machine that measures the quantity of heated meal delivered from the kettle, so as to form one cake at a time. The kettle and the molding and compressing machine are combined together for automatic working, with a great saving of labor and increase of production. At the second pressing, the oil flows into a receptacle at the bottom of each press, and is then pumped into special oil-collecting tanks, each fitted with three divisions. The cakes from this pressing are cooled in racks, pared to give the cake uniform size and then taken to the cake-house. The parings are reground and mixed with meal for the second pressing of the next series. Some factories produce cakes containing about 5% of oil for cattle-feeding purposes. Others prepare cakes holding not more than 1% of oil and sell them as manure.

An effort was made to compare the native method of oil extraction with that of the Philippine Vegetable Oil Co., Manila, but without success, for the manager, in reply to the writer's request for information and permission to visit the factory, stated that it was the policy of the company not to allow any one to enter their factory save the employees and not to give information about their business. However, according to the *Manila Guide* of 1914, coconut oil extraction of 93% is effected in the Philippines by the modern methods.

METHODS RECOMMENDED FOR IMPROVING THE COCONUT OIL INDUSTRY

The coconut growers and manufacturers do not sell their products directly to the consumer. They depend on the local middlemen and many times they receive a price much below the value of their products. A very serious difficulty is the frequent agreement among middlemen to fix a minimum price for the oil. This is done by those who buy at the factories in some of the coconut regions or in the markets. Under such conditions all of the oil is sold at a low price, superior and inferior oils both selling at ₱7.00 per can at the time of this investigation. The manufacturers with an unusually fine quality of oil are compelled to receive the same price as the one having oil of poor quality. When this condition exists, competition is eliminated, trade is restrained and the producer is compelled to take the price offered by the middlemen.

Another difficulty lies in the fact that the returns for the labor and capital of the producers are partly dependent upon unregulated action of the transportation companies. For example, a steamship company carrying copra does not provide a suitable boat for it, the copra is often thrown on the deck exposed to the rain, waves, and water used in washing the deck, and thus deterioration is hastened.

The conditions enumerated above offer an opportunity for suggestions as to their remedy and for the improvement of the coconut-oil industry in general. To this end the writer recommends that the production, manufacture and marketing of coconut products all be done through cooperative association. Without going into details a general description of such an association might be given here.

Nature of Association.—A non-profit association is recommended, for it represents the ideal type of cooperation. The members of the association should have an equal voice in its management and share proportionately in its benefits and risks. Such an organization should be a voluntary industrial democracy in which the producers and manufacturers collectively should manage and control the distribution and marketing of their own products. Every member of the association should be a *bone fide* producer or manufacturer and his products should be handled exclusively by the association After operating expenses, depreciation, and a reasonable interest, say 10% annually on the capital invested are deducted, the proceeds should be distributed *pro rata* among the members. The supervision of the affairs of the association should be vested in a board of directors selected by the members, which should manage and control the business through officers or agents appointed by the board and subject to its advice and direction.

Organization.—The first step after organizing a cooperative association of this type is to incorporate it under the laws of the Philippines.

The association should be incorporated on broad lines. The articles of incorporation should set forth the purpose for which the association is formed and should provide for every activity in which it may wish to engage. They should define the principal place of business, the life of the association, the number and the powers of the directors, the voting power and property rights of the members, the amount of capital stock, and all other things of general nature that should be included in the incorporation of such an association.

A code of by-laws should be adapted for the government and management of the association. These by-laws should

define the methods of exercising the power of the association through the board of directors and the officers appointed by it, the condition governing the admission of members, the dues or stock to be paid by each and the regulations affecting the same. They should provide broad powers for the manager, including, the supervision of the harvesting, aging, manufacturing and marketing of the products or such of these operations as the association may wish to perform. They should adopt a standard for the products, for instance copra containing not over 5% of moisture and oil of superior quality only. They should contain a provision by which the grower and the manufacturer give the association the exclusive right to market the products. These objects are attained by the signature of the farmer and the manufacturer to the by-laws of the association; or the association may require a special contract to be executed with the cooperating member.

The method of providing money for operating expenses, such as by fixed assessment on every can of oil handled, and the methods of pro-rating the balance if the total amount of assessment amounts to more or less than the operating expenses, and other things usually included in such organizations should be set forth in the by-laws.

Management of a Cooperative Association.—The association should have a manager who is competent to assume the general direction of the affairs and business of the association. He must have a high order of business ability, sterling integrity, unusual tact, judgement in handling men and great energy.

In a cooperative association the manager should be subject to the advice and control of the board of directors, for the farmer and manufacturer who oin with their neighbors in such an association are not likely to take much active interest in the management of the association. A manager who cannot make them feel that they have a voice in the management, and who fails to follow a progressive constructive business policy will fail in handling any cooperative association. It is not an exaggeration to say that no single factor has operated against the success of the cooperative association as much as the incompetent manager selected by the directors of the association.

BENEFITS OF CO-OPERATION

1. Coconut Production.—The gross coconut production seems to fall short of its maximum every year due to poor cultural methods. In some places the plantations are very weedy. Weeds of all kinds carry on a keen competition with the coconut tress. The presence of these obnoxious plants is detrimental as is well shown by the behavior of the growing crop. Coconut trees surrounded with bushes and weeds do not bear as many nuts as those of which the bases are free from undesirable plants. Some plantations are clean, yet un-productive because the soil is depleted by long and constant cropping. Still other plantations are very unproductive due to lack of water. Again, it is observed that in some coconut regions the trees are constitutionally weakened by fungous diseases, or by the *Oryctes rhinoceros* Linn, the "uang."

The results of such cultural methods may be remedied by improving the crop by associated, rather than by individual, effort. Cooperation may be satisfactorily applied to such details of the production of the crop as pasturing cattle in the coconut plantation, raising legumes and plowing them under the interspaces, in the irrigation of the land, and the spraying of the infected trees which, to be effective, must cover large areas.

2. Manufacture of Coconut Products.—Coconut products could be prepared profitably under cooperation. Small oil factories, or *lacgisan* and almost insignificant *tapahan*, copra drying plants, are numerous in the coconut regions preparing oil and copra for the market by more or less unprofitable methods. In the factories, also the nuts are opened when of varying degrees of ripeness. The manufacturers are throwing away oil with the cake; are turning out improperly dried copra, either burned or containing much moisture; and hence are spending money, time and effort with little or no profit. Financially no one of them can afford to equip a modern oil and copra-drying plant, for, according to the Pacific Commercial Company of Manila, the installation of such a plant involves a minimum cost of about ₱35,000. If the work of the small factories was done cooperatively by one larger factory using modern and scientific methods, greater profits would be secured.

3. Marketing Coconut Products.—The marketing of coconut products can be successfully carried out under cooperation. A very satisfactory plan in marketing copra and oil is to send to the trade in advance of the shipment catalogs and samples of the probable qualities and quantities of copra and oil that the association has for sale and then to sell the products directly to the highest bidder. As to transportation, the Philippine Legislature should be asked to pass laws prescribing rules and regulations governing the charges which transportation companies may make on the products, and the methods of carrying the products. As individuals, of course, coconut growers and manufacturers cannot deal as effectively with the transportation companies, courts, or legislature as when organized into cooperative associations.

Other general suggestions for improving the coconut products have been given. They are; (1) more care in the curing and handling of the copra and oil, and (2) proper selection of nuts with respect to age. The conditions in which the coconut products reach the consumer depend largely on the care with which they are handled. The best method of picking and aging the nuts is to allow them to fall by themselves and to store them for about three months before opening, the copra and oil thus increasing proportionately. The rapid deterioration of Philippine copra can be remedied by drying it so that it contains not more than 5% moisture. If the coconut oil is prepared in a pure state, its keeping qualities can be made equal, if not superior, to other vegetable fats and oils.

To help out coconut farmers and manufacturers, the Insular Government has enacted laws creating "a board to promote the improvement of coconut products"; and providing punishment for those who steal or destroy the coconuts. People engaged in coconut industry should therefore familiarize themselves with Acts Number 2598 and 2609 of the Philippine Legislature, and should not hesitate to urge the passing of other laws that would be of benefit to the coconut industry.

SUMMARY

In the attempt to determine the efficiency of the native oil-press method by field investigation and experimental data the following observations were made:

1. The native husker, *tapasan*, is very efficient.

2. To increase the production of oil, the teeth of the scraper, *kabyawan*, should be made very fine.

3. The rectangular furnace fitted with one chimney and two caldrons is more effective than the conical type.

4. To save material and time the boiling caldrons should have higher sides.

5. The rattan bags, *andulan* need no substitute.

6. The double-screw type of press, *hapitan*, works three times as fast as the single-screw type and gives greater compression.

7. Galvanized troughs, *banka*, should replace all wooden troughs.

8. For storing oil, "standard oil" cans and galvanized cylindrical tanks should take the place of earthen jars, *tapayan*.

9. The practice of paying separately for husking, scraping and for each can of oil extracted, gives the fairest wages in labor management in the oil factories; by other practices the laborers are either underpaid or overpaid.

10. The native method of oil extraction requires from 5 to 5.5 days per charge. Charge here means the number of nuts worked upon at one time.

11. The quantity of oil extracted from a given quantity of nuts varies according to the size and degree of ripeness of the nuts used.

12. The amount of cake in a nut varies directly with its oil content.

13. The net profit per thousand nuts depends (1) upon the buyer's ability to select profitable nuts and to pay a fair price for them, and (2) in the manager's selling the products at normal prices.

14. The total amount of oil in a nut (among those studied) runs from 40.1% to 64.6% and averages 54.4% of the dry weight of meat.

15. In the native scraping operation from 1.6% to 10.3%, or an average of 6.0 of oil, is lost.

16. In boiling coconut meat, from 0.4% to 3.5%, or an average of 2.0% of the oil, is lost.

17. During fermentation the moisture in the meat increases or decreases according to atmospheric conditions and the natural factors.

18. Due to the porosity and the construction of the native grinder, from 6.2% to 15.1%, or an average of 10.7% of oil, is lost.

19. By the native method, from 2.9% to 13.9%, or an average of 8.4% of oil, is thrown away with the cake.

20. The kind of press employed does not wholly determine the percentage of extraction; this is influended by the physical condition of the coconut meat and the effect of fermentation on it.

21. From 4.8% to 8.4%, or an average of 6.6% of the oil, is thrown away with the *latic*.

22. The loss of oil by leakage through the throughs and by piling the coconut meat on the ground was not determined but since loss from this source is known to occur the calculated efficiency must be correspondingly high.

23. The total loss of oil by the native method averages 34.5% of the total oil.

24. The efficiency of extraction by the native method ranges from 41.4% to 75.2% and averages 65.5% of the oil.

25. Native methods of oil extraction are slow and unprofitable compared with modern methods of oil extraction.

26. Oil extraction by modern methods is claimed to be 93% efficient as against 65.5% by native methods.

27. The running of coconut oil factories depends on the yield of coconut and is intermittent on this account.

28. As a result of the foregoing study the following suggestions for the improvement of the coconut oil industry are offered.

29. Cooperation is urged as a remedy against the loss of money due to poor cultural methods, to the improper pre-

I	II	X	XI			XII
		ceeds		*Cost*		
Factory No.	*Location*	*Value of Cake per 1,000*	*Total Income*	*Cost of Nuts per 1,000*	*Cost of Extraction per 1,000*	*Total Cost*	*Gain*
1	Oples, Lilio.....Mr. Jo	₱ 1.50	₱24.25	₱16.00	₱ 5.00	₱21.00	₱3.25
2	Near R. R. Station, Magdalena Mr.	1.05	24.43	14.50	4.75	19.25	5.18
3	San Sebastian, Pagsanjan.....Mr. M	0.02 (not reliable)	9.85	27.00	0.68	27.68	7.83
4	San Sebastian, Mr. B Pagsanjan...	1.04	28.04	21.50	3.52	25.02	3.12
5	San Sebastian, Pagsanjan.....Mr. P	1.56	33.63	24.00	5.13	29.13	4.50
6	Bukal Magdalena.....Mr. R	1.25	26.83	15.00	2.40	17.40	9.43
7	Sagrado Corazón Magdalena.....Mr. L	0.60	17.92	15.00	5.50	20.50	2.58
8	Tignay, Mr. A Magdalena.....	1.20	26.32	18.00	5.00	23.00	3.52
9	This is factory No. 2 management.....	1.23	23.87	19.00	4.75	23.75	0.12
10	San Isidro Lilio.....Mr. C	0.35	20.88	17.50	2.63	20.13	0.75
11	Dita, Lilio.....Mr. T	0.33	25.70	22.50	2.63	25.13	0.57
12	Dita, Lilio.....Mrs.	0.80	26.16	14.50	2.15	16.65	9.51

red	VIII Amount of Oil per 1,000	IX Amount of Cake per 1,000	X Proceeds Value of Oil per 1,000	Value of Cake per 1,000	Total Income	XI Cost Cost of Nuts per 1,000	Cost of Extraction per 1,000	Total Cost	XII Gain
ys	5	5	₱22.75	₱ 1.50	₱24.25	₱16.00	₱ 5.00	₱21.00	₱3.25
	5.5	3.5	23.38	1.05	24.43	14.50	4.75	19.25	5.18
	1.31 (not reliable)	0.13	9.83	0.02 (not reliable)	9.85	27.00	0.68	27.68	7.83
	4.5	4	27.00	1.04	28.04	21.50	3.52	25.02	3.12
	5.5	6	32.07	1.56	33.63	24.00	5.13	29.13	4.50
	4.8	5	25.58	1.25	26.83	15.00	2.40	17.40	9.43
	3.25	2	17.32	0.60	17.92	15.00	5.50	20.50	2.58
	4	4	25.32	1.20	26.32	18.00	5.00	23.00	3.52
	4	3.5	22.64	1.23	23.87	19.00	4.75	23.75	0.12
	4.25	3	20.53	0.35	20.88	17.50	2.63	20.13	0.75
	5.25	3.25	25.37	0.33	25.70	22.50	2.63	25.13	0.57
	5.25	4	25.36	0.80	26.16	14.50	2.15	16.65	9.51

paration and handling of coconut products, and to the combined work of the middlemen.

30. Adoption of modern methods is essential to increase the copra and oil production.

31. Nuts for copra and oil manufacture must be properly aged to insure a maximum yield.

32. The passing of laws facilitating the transportation of coconut products should be demanded from the proper authorities.

ACKNOWLEDGEMENT

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EXPLANATION OF PLATES

PLATE I

Fig. 1. Native scraper, or *kabyawan.*

Fig. 2. An improved coconut-meat scraper.

PLATE II

Fig. 3. A native furnace for cooking coconut milk.

Fig. 4. Native coconut-meat grinder.

PLATE III

Fig. 1. Native oil press, single-screw type.

Fig. 2. Native oil press, double-screw type.

Fig. 3. Wooden oil trough.

Fig. 4. Galvanized-iron trough.

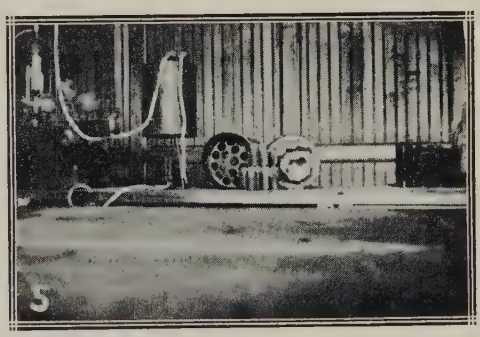
Fig. 5. Laboratory oil extractor.

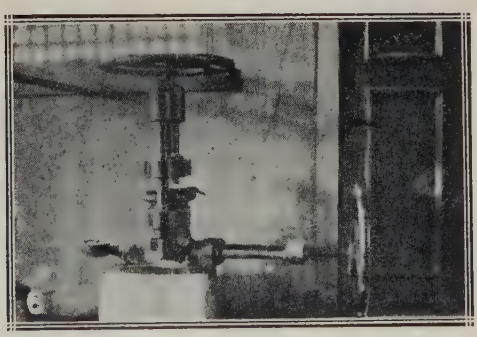
Fig. 6. Modern hydraulic oil press.

PLATE I

PLATE II

PLATE III





Culture and Fertilization as Affecting the Oil Content of Peanuts

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Thes s presented for graduation from the College of Agriculture, No. 70.

INTRODUCTION

The enormous consumption of peanuts and peanut oil and the increasing demand for these products, due to newly discovered uses as food, place peanuts upon the list of crops which should be actively improved. The principal centers of the peanut oil trade are France, Italy, Spain, and the United Kingdom. More recently the peanut has gained favor for table use in the United States, so that the United States is now an importer, in spite of the fact that peanuts are raised there is great quantities. Her imports during 1913 and 1914 show an average of ₱3,421,401 worth of peanuts and peanut oil, which she pays annually to peanut-exporting countries. (1) Marseilles is the most important center of the peanut-oil trade. In 1912 over 120,000 metric tons of peanuts in the shell, together with about 240,000 metric tons of shelled nuts, were crushed in Marseilles, yielding 15,500,000 gallons of edible oil. In addition to this, about 23,000,000 gallons of inferior peanut oil were produced. (2) There are, in France, efficient and elaborate factories for extracting the oil from the nut. Because of these machine methods, it used to be more profitable to export hulled nuts than oil but the recent rise of freight rates and the utilization of the factories for other purposes due to the war, make preferable the crushing of peanuts before shipment. Besides Egypt and the West African sources, peanuts are exported from the East from India, Burma, China, and Japan. In Madras, the center of the British India peanut industry, peanut growing is the chief source of agricultural wealth. To this industry are devoted 1,441,000 acres of land. (3) British India exports annually about six million dollars worth of peanuts and peanut oil, over five millions of which go to France. China, Burma, and Japan export annually great quantities of peanuts and peanut oil which mean material income to those countries. (4, 5, 6, 7, 8) The Philippines, in the vicinity of these exporting countries, and no less favorable for peanut growing imports peanut products to an extent that speaks unfavorably for its economic development.

A review of the Bureau of Customs Reports since 1911 can not fail to reveal to students of Philippine economics some of the miserable agricultural conditions in these Islands which may be remedied by investigations tending to the improvement and extension of the cultivation of certain crops. We note the tremendous imports of agricultural products which can be easily grown here. Especially is this true of peanuts, the subject of the present study. It will be seen from the accompanying table that the Islands annually import peanuts valued at ₱137,685 and peanut oil worth about ₱160,091, making a total import of ₱287,676. For 1913, the peanuts and peanut oil brought into the Islands amounted to ₱390,362, a sum sufficient for the expenses of the College of Agriculture for two years. The sum of the imports for five years beginning 1911 totalled ₱1,478,878. There is no particular reason why we should send away this annual tribute to other nations for a commodity which is not a part of our necessary daily diet, being eaten only at odd times and which

can easily be produced here. At present peanuts are not consumed as a regular article of diet nor are the uses of the oil and oil cake understood. How much more will our imports be if steps are not taken to popularize its culture in the Islands, when peanut finds a regular use as a source of protein for the body, its oil is used instead of olive oil and its meal is used as a feeding stuff? Excluding foreign markets, where there is always a market demand, the home consumption is already a guaranty for a good market for peanut products.

TABLE SHOWING ANNUAL IMPORTS

	Peanuts		*Peanut oil*	
Years	*Kilos*	*Value*	*Liters*	*Value*
1911	842,535	102,138	518,341	125,832
1912	1,088,468	134,804	700,064	172,500
1913	1,148,877	171,580	790,667	218,782
1914	1,216,267	161,266	578,372	160,758
1915	1,002,459	118,638	493,555	112,586

TABLE SHOWING IMPORTS AND ORIGIN OF PEANUTS

	1914		*1915*	
Origin	*Kilograms*	*Value* ₱	*Kilograms*	*Value* ₱
United States	1,506	440	588	295
China	1,010,114	143,968	997,616	117,786
German-China	191,859	14,862		
British E. Indies	7,404	1,158	1,666	241
Dutch E. Indies	4,598	614		
Japan	1,236	224	2,589	316
TOTAL	1,216,267	161,266	1,002,459	118,638

PEANUT OIL

	Liters	*Value* ₱	*Liters*	*Value*
TOTAL	578,372	160,756	493,555	112,586

POSSIBILITIES OF PEANUTS IN THE PHILIPPINES

Although there has been a good demand, as shown by the imports, the growing of peanuts has not attracted any real investment. Except in very few localities, peanut growing is practically a garden crop for local consumption. There are no extensive plantings of peanuts in the Philippines, and no machinery for preparing the products. Near Manila, peanuts are raised in San Mateo and Montalban and the product is sold to the Chinese who use it for adulterating chocolate tablets. In Batangas and Lemery a variety is grown for its vines which are fed to horses. Due to lack of definite statistics it is impossible to give the regions growing peanuts and the amount of output. Information gathered from students of this college, who represent almost all parts of the Philippines, gives evidence that peanuts are grown successfully in many localities, but on a limited scale, hardly enough to supply the local demand. It is evident that peanuts can be grown in the Philippines and it is only a question of selecting the best adapted varieties for each locality in order to make profit a certainty. Ignorance of the proper methods of culture and of the possibilities of gain are probably the explanation for the non-existence of an extensive peanut industry. In the United States the peanut had a similar beginning. It was necessary that its use gradually develop and its culture and preparation for market be made a real study before the industry grew to its present state. The Year Book for the year 1911 of the United States Department of Agriculture says: "The peanut investigations have caused rapid extension of the industry. From a beginning of a few hundred acres in 1908, the crop this year will require more than 300,000

acres in the Gulf States alone where prior to the time mentioned no commercial industry existed." The same course could be followed in these Islands. Every crop from which profits can be obtained should be made the subject of real study. When more definite information has been acquired by extended investigations in regard to cultivation, adaptabilities, peculiarities, oil content and uses peanut growing will undoubtedly be rapidly extended.

The variety of uses of the products of a plant determine the relative value of that plant as a crop. In other words, the more numerous the uses for the products, the greater the demand and consequently the better the price. The peanut is second to no other agricultural product in diversity of uses. Besides being a legume which makes it valuable as a soil renovator, the forage is a first class feed for stock, with a nutritive value that compares favorably with the best legume hay, and the nuts are either consumed for food or made to yield peanut oil, one of the best known vegetable oils. For human consumption the nuts have a wider range of uses than any other legume. In the Philippines the nuts are universally eaten as roasted or salted peanuts and in some form of sweet or candy. In enters into an innumerable number of recipes. Peanut butter is a new product, but promises to become universally popular and already is in great demand. Recent investigations have demonstrated the peanut to be the cheapest meat substitute in a vegetarian diet. "When considering nuts, it is readily observed that 10 cents will buy the same amount of nut protein as of animal protein except in case of cheese and skin milk. If spent for peanuts it will purchase more than twice the protein and six times the energy that could be bought for the same expenditure for porterhouse steak." (9) Ten cents worth of peanuts will contain about four ounces (120 grams) of protein and 2,767 calories of energy which is more protein and energy than is furnished by many rations regarded as adequate for a day. The oil is becoming popular for salad purposes. It is used to adulterate olive oil and to improve the quality of cotton seed oil for table uses. It is used for various technical purposes and for manufacturing fancy soaps. After the oil is extracted a by-product is left which contains a very high muscle-building property (protein). (9)

These diversities of use and the numberless ways by which the producer can dispose of its products entitle the peanut to an important place on the farm. As evidence of value as fodder, the region around Batangas, Lemery and Taal, which produces the best horses of the Philippines, grows peanuts for forage to feed the horses. The nuts can be used directly on the farm by transformation into pork, a practice which saves the expenses of harvesting; (returns the manure of the animals to the ground) and if properly done is a cheap method for producing pork. An experiment in the Alabama Experiment Station (10) shows peanuts or peanuts and corn meal to be cheaper than corn meal alone for pork production. The writer says "At the close of the sixth week it was found that 2.8 pounds of peanuts alone or 3.7 pounds of equal weights of peanuts and corn meal had been consumed for each pound of grain, while 10.7 pounds of corn meal alone had been needed to make the same growth. It is the general opinion gathered from different investigations that peanut as an adjunct to corn is valuable for the production of high grade hams and bacon. When used for peanut oil production, the by-products serve as fertilizer or feed for the farm animals.

PREVIOUS WORK ON PEANUTS

The field for investigational work on peanuts in the Philippines is large and as yet practically untouched. So far there is only one published work on the subject and the results are merely a preliminary breaking of the ground. There are the problems of acclimatization and selection, both for strains with high yields and those with high oil content. There are also the questions of the relation of oil content and maturity. Still more important is the real value of the peanut as a crop in rotations. The present study is not intended to solve all these problems but to determine certain facts as to production and oil content under local condition.

Consunji (12) found that fertilization with stable manure and wood ash gave an increase in the production of pods. He obtained with wood ash, an increase in the weight of the pods of 7.3% for the American variety, 36.7% for the Calcutta and 16.9% for the Spanish C. A. With stable manure the increase in the weight of pods obtained was 38.1% for the American variety. Beattie (13) considers that wood ash is a good fertilizer for peanuts and remarks that if stable manure be used, it should be applied with the crop preceding the peanuts. There are tons of stable manure going to waste every year in almost every town of the Philippines, which, we hope, will find application in the field in the immediate future, whether for peanuts or other crops. Similarly there are tons of ashes from our rice mills and other factories, which instead of being saved are thrown into rivers. In view of these facts and in the hope of finding some relation between the fertilizers and the oil content, a study of the comparative oil content of the different varieties and the effect of the application of natural fertilizers upon the oil content was undertaken. The importance of a comparative determination of the oil content of the different varieties for selection work cannot be too strongly emphasized. It is also unwise for a farmer to go into peanut growing for oil without knowing which variety will give the highest content for his locality.

EXPERIMENTAL WORK

The experiments consist of the fertilization of six standard varieties of peanuts, with stable manure, wood ash and a mixture of ash and manure and a series of determinations of the oil content of each under different treatments. The varieties used were: American 109, Big Japan 3079, Kinorales 3083, native Lemery 3082 and two evidently Chinese peanuts, but named according to the source of seeds, the San Mateo 5958 and the Montalban 5957. The fertilizers used were obtained locally, the manure collected from the stables from the barrio in the vicinity of the college, and the ash obtained from the boiling plant of the College of Agriculture. The determination of oil was conducted in the Chemistry Department of the College of Agriculture.

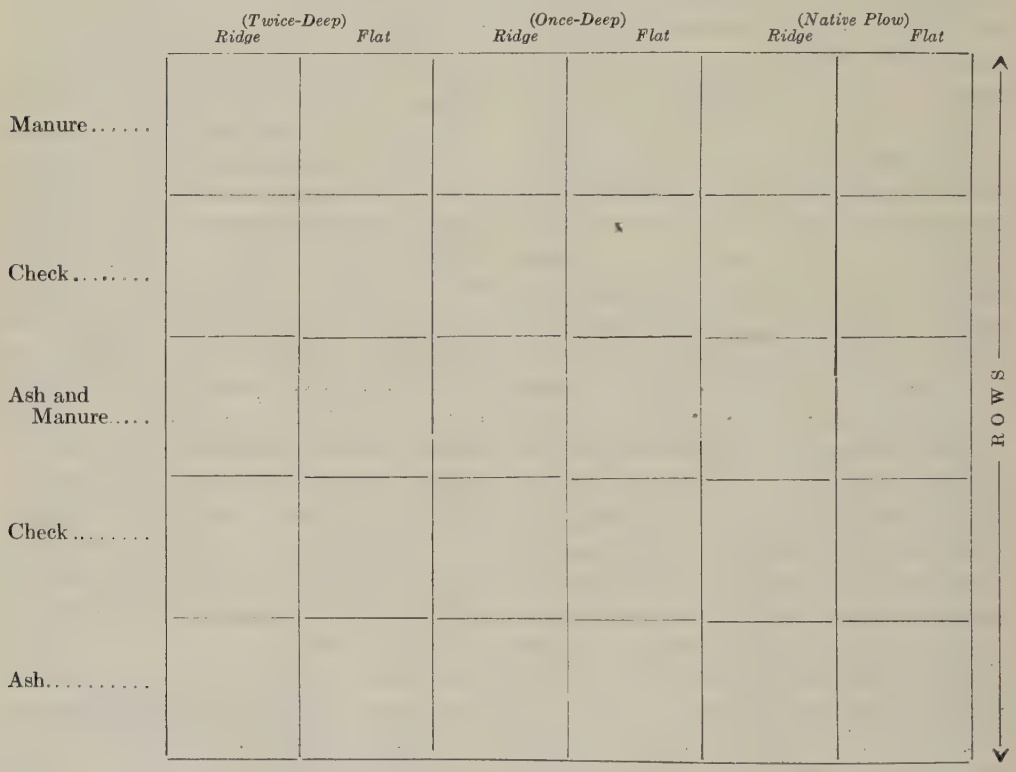
Sources of variation in the results: Besides weather irregularities and the fact that plant food is not very uniformly distributed in the surface layer of a given area of ground, there are still several factors which are responsible for the variation in the results of a fertilizer experiment. Weeds, if not placed under control, may counterbalance the good effect of the fertilizers. Animals, insects and fungous enemies of the crop would have similar effect. Rats may destroy a portion of the crop in the field. Insects and fungi may attack a certain portion of the field and thus hamper that portion in its normal

growth or production. Then there is a trouble with peanuts which is not often encountered in the work with other crops, the loss in harvesting. Peanuts have a peculiarity of maturing the pods underground, and in harvesting, there are commonly many nuts left in the ground which are not accounted for.

In all the plantings check plots were used, and in the analytical work blanks were always run and all necessary precautions to eliminate available sources of error, taken. Due to numerous causes of variation in the results, only the most obvious conclusions will be given.

Agronomical Data. The field for these experiments was 50 meters by 27 meters, divided into sections and treated according to the following plan.

FIELD PLAN OF CULTURES



The soil for this culture had been previously put to rice and corn successively. It is characteristically a heavy clay loam, not the ideal one for peanuts, but one typical of most agricultural soils of this section of the Philippines.

The field marked "Twice Deep" was prepared with a heavy plow drawn by two vacas. The section was plowed twice. The "Once Deep" section was prepared with the use of the same plow but plowed only once. The "Native Plow" section was prepared by using the native plow which works the soil much shallower than the big plow. The field was given equal and uniform treatment for the rest of the work necessary, except in those conditions in which the experiments were required to vary. Each of these sections was again divided into "Ridge" and "Flat" signifying the kind of cultivation that was given to the crop. For the ridge cultivation the native plow was used

during the first cultivation, the soil being turned toward the hills. In the second cultivation the ordinary one-vaca double-shovel plow or ridging plow of the college was used. For the flat cultivation, the ordinary one-animal five-tooth cultivator was used. In this treatment the object was to loosen the surface soil without throwing the soil toward the rows as in the ridge cultivations.

By running the fertilizer application across the division of the field, it was possible to treat each division similarly with fertilizers as provided in the experiments. The amount of manure applied was 57 petroleum cans. At this rate and at the average weight of a can, 9.5 kilos, the manure section of the experimental field received 542.9 kilos of stable manure. This is equivalent to 21,687 kilos per hectare. The number of cans of ash applied was 20. At 9.0 kilos per can of ash, the total amount of ash used was 180 kilos equivalent to an application of 7200 kilo per hectare. The amount of mixed fertilizers applied was a combination of 10 cans of ash and 15 cans of manure amounting to 232.8 kilos of the mixture equivalent to 9315 kilos per hectare.

The application of fertilizers was made by hand, spreading them uniformly on the surface of the field after its preparation. To work the fertilizers well under the surface and mix them thoroughly with the soil the disk harrow was passed over once and the surface then smoothed with the native bamboo and harrow (*calmot*). As this extra treatment would mean an improvement in the physical condition of the surface soil, the whole field, including the blank, was given the same uniform treatment. To provide for drainage during the rainy season, ditches or drain canals were built around the experimental field.

Plantings were made six days after the application of fertilizers. The order and arrangement of the varieties in all sections were exactly the same. The long vine or spreading varieties, namely, the American, the Native Lemery, the Big Japan, the San Mateo and Montalban were given the distance of 100 centimeters x 50 centimeters and the Kinorales 80 centimeters x 40 centimeters. Plantings were made on the 19th and 20th of May, 1916. The Kinorales germinated on the 24th and the big varieties germinated five to six days after planting. The hills which failed to germinate were replanted.

The occasional rains during the first week favored the early development of the plants but necessitated the cultivation of the ground to keep the surface soil loose and pulverized. For the first cultivation the native plow was used to throw the soil toward the hills and the one-animal double-shovel plow cultivator was used in the subsequent cultivation for all the plots which required ridge cultivation. The one-animal five-tooth cultivator was used in the cultivation of all the flats requiring flat cultivation. Ordinarily, peanuts are given two cultivations but, because of the rains, it was necessary to give this culture three cultivations to prevent the soil from baking and to keep the surface loose. All the cultivation necessary to keep the soil in good tilth was made before the vines had covered the whole ground, otherwise cultivation would have been impossible.

The ridge cultivation has an advantage during the rainy season in providing a good drainage for the surface water. In the dry season however it has the disadvantage of allowing more rapid drying of the ground.

The justification of any one practice however depends upon its influence on the final product for which the crop is planted and the judgment as to which

is preferable, based upon the present experiments, will be given in the discussion of the results.

Observations on the relative susceptibility of the different varieties to *Cercospora personata*, the leaf spot disease very common in all the peanut-growing regions, gave proof that the native Lemery is the most resistant, followed in the order given by the Big Japan, the San Mateo, Montalban, and the American. The Kinorales is fairly resistant. The varieties were planted in culture side by side so that one glance during the stage when the leaf spot was abundant in the field, showed which variety was most susceptible at that age. It appears that, like other fungous diseases, the condition favorable to the spread of the leaf spot is dampness, so that in deciding distances for any given variety one must take this fact into consideration.

The harvesting methods and the proper time for harvest are other distinct problems. The fruits are underground and indications of the time at which the maximum product can be obtained have not been established for any variety. The fruits can not be harvested, as they mature, as we do with our beans, but at harvest time, the whole plant must be dug up so that the immature fruits go to waste. It has been found also that some of the fruits mature and germinate while other fruits are being developed. The problem therefore is to determine the stage when the most can be obtained at the sacrifice of the undeveloped pods or of the overmature pods. But this is not the purpose of this work, and the time of harvest for each variety in the experimental cultures was based upon the work of Consunji (12) and on common practice. There are several methods of harvesting peanuts. Where the soil is loose and sandy, the plants need only to be pulled up and the pods come up with the stem. In heavy and clayey soils, this can not be practised and harvesting is done with the aid of a dibble or fork or any similar instrument. For the purpose of the experiment, harvesting was done with the aid of a spading fork, and due care was taken so collect all the pods possible.

Peanuts may be grouped into late, or long season, and early varieties. The Spanish and the Kinorales are the early varieties and those which have long spreading stems like the American and Big Japan are the long season varieties. The Kinorales was harvested August 16, 1916 to August 19, 1916 about three months from the date of planting. The long-season varieties, the Native Lemery, Big Japan, American, Montalban and San Mateo were harvested during the first week of November, 1916. It was noted in the course of harvesting that the Kinorales was easier to harvest than the long-season varieties because the fruits are developed at the immediate base of the plants forming a big cluster. In harvesting, one needed only to dig around the base of the plant, while with the other varieties it was necessary to follow the stems one by one. The fruits of the Kinorales do not easily fall off as do those of the large varieties. In harvesting the number of hills and the weights of the pods from given sections were noted so that by dividing the weight of the pods obtained by the number of hills, an average per hill was obtained from which the yield per hectare was computed.

Results: All results were computed to a hectare basis for purposes of comparison. The weighings were made in grams but were reduced to its equivalent number of pounds on the hectare basis. The results are given in tables 1 to 6. The comparative yields per hectare on check plots are as follows:

	Pounds	*Computed kilos*
Montalban	3183.47	1447.01
American	3782.80	1719.45
Big Japan	3147.80	1429.45
Kinorales	2659.73	1208.96
Native Lemery	2328.74	1058.50
San Mateo	3647.64	1658.01

Accordingly, the American leads in production followed by San Mateo, Montalban and Big Japan. The tables also show that of the two methods of cultivation used, the flat gave better result for the production of pods. The flat shows an increase of from 250.79 lbs. in the case of the American variety, to 1011.83 lbs. in the case of the Montalban, of marketable pods, over the ridge cultivation. These represent an increase of from 5% to 24% of the weight of pods. This indicates that in the culture of peanut on our soil and under local conditions it is essential only to keep the surface loose and in a condition favorable for the penetration of the developing ovary and that any effort to hill the soil toward the row would result in a wasted effort and loss.

It is a common practice among the farmers to run over the field a long piece of bamboo to make the stems lie flat on the ground. Often they even go to the extent of covering the stems with soil, when the plants are in bloom in an effort to get more pods. The present experiments show that, provided the surface soil is favorable for the development and penetration of the pods, the plants give very favorable results without further attention. These results agree with similar experiments performed at the Nebraska Experiment Station (14). The present work proved that level cultivation yielded more pounds to the acre than the ridged cultivation. According to E. B. Ferris (15). "The old practice of drawing dirt on top of the vines as they go to fruit not only is expensive and does no good but according to the best authorities is positively injurious."

The table shows that in the majority of cases the ash gave greatest increase, the manure and ash mixed, following, and the manure alone the least. This is true with Montalban, Big Japan, Native Lemery and San Mateo.

A critical study of the following table will show the very marked effect of fertilizers:

A SUMMARY TABLE SHOWING THE INCREASE DUE TO FERTILIZERS

Varieties	*Manure*			*Ash*		*Mixed*	
	Yield in pounds per Ha.	*Yield in pounds per Ha.*	*Increase*	*Yield in pounds per Ha.*	*Increase*	*Yield in pounds per Ha.*	*Increase*
Montalban.....	3183.47	3744.87	561.40	4243.6	1060.13	6382.3	639.53
American.....	3782.8	5392.8	1610.00	4858.3	1075.5	4440.13	659.33
Big Japan.....	3147.8	4630.05	1482.25	4657.8	1510.00	3697.	549.20
Kinorales.....	2659.73	3962.9	1303.17	3322.7	663.02	3112.73	453.00
N. Lemery.....	2328.74	2964.8	636.06	3059.9	731.09	2052.3	—276.44
San Mateo.....	3647.64	4213.7	566.06	4327.8	680.16	3613.3	—34.34
Average.....			1026.49		953.33		575.26

Analytical Results. The oil analyses show very uniform positive results and indicate that along with the increased yield of pods due to fertilizers there is also an increase in the oil content. Tables 7 to 12 will indicate this.

The determination of the oil content for each variety and for each section was made on representative samples. Each lot was separately sorted and shelled and the sample was obtained after each lot had been thoroughlymixed. The samples were as well cured as when obtained in the market. The results of analysis were obtained by difference before and after extraction and the apparatus for extracting oil used was a laboratory oil extractor made locally. This apparatus had been successfully used for this purpose by Mr. Vista in the analysis of coconut oil for his thesis (16) by Mr. Villyar (q. v., this

issue) also for determining coconut oil from cakes obtained from native press, and by other students whose work is yet unpublished.

The results indicate that of the different varieties the Kinorales has the highest oil content giving an average of 57.40% of oil calculated on the dry basis for the check cultures. The big Japan gave an average of 48.75%, and the American 47.38% of oil, calculated on the dry basis for the check cultures.

The relative oil content in the different sets for each variety are given in the tables of per cent of oil content. It is evident from these results that fertilizers, manure, ash, and mixed ash and manure increase the oil content of the peanuts.

	Checd	*Manure*		*Ash*		*Mixed*	
	Oil Content	*Oil Content*	*Increase*	*Oil Content*	*Increase*	*Oil Content*	*Increase*
Big Japan.....	48.75%	50.06%	1.21	52.94%	4.19	52.85%	4.10
American.....	47.38%	50.51%	2.13	52.29%	4.91	53.68%	6.30
Kinorales.....	57.40%	55.04%	—2.36(a)	57.45%	0.05	57.40%	0.00
Montalban.....	51.42%	52.67%	1.25	54.83%	2.41	53.74%	2.32
N. Lemery.....	49.93%	49.91%	—(0.02)	52.43%	2.50	51.07%	1.14

(a)—Indicates below check.

It is evident that ash, and the mixed manure and ash gave the best results. The manure gives the minmum increase. It is very probable that maturity has direct relation to the oil content and that there is a point of maturity of the pods at which time the oil content is at its maximum. Each variety may have a different time of maturity for this maximum oil content. If this be true, the explanation of the results may be that as manure contains more nitrogen it induces more vegatative growth and therefore extends the time of maturity, while the ash and the mixture contain more of the plant food elements that induce early maturity. Since in the cultures the crop had exactly the same length of time between planting and harvesting, it would follow that the pods in the ash and mixed-fertilizer cultures must be relatively more mature or nearer to the maximum oil-content point, than those in the manure cultures. This suggests a new problem, namely that for every variety or strain the maximum-oil-content stage should be determined in culture with fertilizers and without fertilizers. We should also determine whether the high oil-content point is correlated with the high-yielding stage. In regard to the last point we already have very interesting positive hints. Take for instance the American variety. The average yield from flatly cultivated cultures was greater than from the ridge by cultivated cultures. By reference to the oil-content tables, we find that the average percentage of oil for this variety in all conditions under ridge cultivation is 49.49% and under the flat cultivation 52.43%. The same effect is noted with the Montalban variety. The yield of pods in all conditions under ridge cultivation averaged 3290.41 pounds and under flat cultivation 4202.24 pounds. The oil content corresponding to these two are 56.81 per cent and 57.28 per cent, respectively.

It will be noticed from the tables of oil content that there is not much difference in the oil content of the different varieties, Big Japan, Montalban, American and San Mateo. It is also noticeable from Table 9 that the variation of the oil content of the Kinorales under different conditions is as wide as the difference between varieties. Comparing the results with analyses of

peanuts grown in the United States (18), the Kinorales, which corresponds to the Spanish variety, gave 57.40%, compared with 52.5 per cent, the average for the Spanish varieties. The average for the Big Japan, American and Montalban is 48.06, corresponding to the Virginia varieties having 43.3 per cent. The per cent of oil given in this work is computed on the dry basis, and the per cent of moisture runs from 6 to 8, so that basing the oil content on shelled nuts cured as given for the American analysis, the results would compare very closely.

A shelling test of the different varieties gave the following average per cent of shelled nuts: Big Japan 69.76, American 66.02, Montalban 68.46, San Mateo 63.62, Kinorales 74.32, and Native Lemery 66.97%. These show that the Kinorales has a larger proportion of meat to shells than any other variety. This characteristic, combined with the higher per cent of oil, quicker maturity and ease of harvesting, make it more desirable for oil production than the other varieties.

SUMMARY OF RESULTS

1. Fertilization with ash, manure and ash, or manure alone, increased the oil content. The ash in a majority of the cases gave the highest increase followed by mixed fertilizers and the manure in the order named. (See table on fertilizers' effect on oil content.)

2. The variation of the oil content due to different conditions for any one variety is as wide as varietal differences. For example, in the Big Japan, the variation for the different conditions is from 48.00 to 53.67 per cent and the oil content of varieties, except the Kinorales, 57.40, is from 47.3 American to 48.75 per cent. (Big Japan.)

3. The comparative oil content of the different varieties is as follows:

Kinorales	57.40%
Big Japan	48.75%
American	47.75%
Montalban	51.42%
San Mateo	
Native Lemery	49.93%

4. The fertilization increased the actual yield of marketable pods (See summary table for yield.)

5. The ridge cultivation gave lower results for yield and oil content than the flat cultivation.

6. The Kinorales, although a low yielder, possesses desirable characteristics that make it preferable for oil purposes. (1) Quicker maturity. (2) High oil content. (3) Ease of harvesting. (4) Erect habit of growth.

CONCLUSIONS

From the above data the following conditions may be drawn:

1. That the application of natural fertilizers should be encouraged because it adds fertility to the soil and increases the yield and oil content of the peanuts.

2. That the Kinorales variety has combined qualities which make it preferable for oil purposes.

3. That flat cultivation is preferable to ridge cultivation for peanut culture in this region.

4. That the oil content is increased by application of ash, mixed fertilizers and manure in the order given.

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TABLES I AND II

YIELD IN POUNDS AND BUSHELS OF GOOD PODS COMPUTED TO ONE HECTARE BASIS

Variety Montalban College Number 5951 F1		*Native*	*Plow Once-Deep*		*Plowed Twice-Deep*		*Plowed*	*Averages*	
		Pounds	*Bushels*	*Pounds*	*Bushels*	*Pounds*	*Bushels*	*Pounds*	*Bushels*
Manure	Ridge	2053.3	77.85	3168.00	121.85	5148.00	198.00	3456.4	132.56
	Flat	3850.0	148.08	3520.00	135.48	4840.00	186.15	4033.3	156.57
Ash	Ridge	3156.0	125.00	2640.00	101.53	4708.00	181.09	3501.3	135.87
	Flat	5280.0	203.00	4048.00	145.69	5632.00	216.62	4986.0	188.43
Mixed	Ridge	2772.0	106.00	3740.00	143.85	3432.00	132.02	3314.6	127.29
	Flat	4549.6	174.98	3564.00	137.09	4884.00	186.84	4332.0	166.30
Check	Ridge	2322.0	90.19	3168.00	121.85	3168.00	121.85	2889.3	111.29
	Flat	3445.8	132.55	3520.00	135.48	3467.20	133.35	3477.6	133.46

Average Ridge 3290.41 lbs.
Average Flat 4202.24 lbs.

Variety American College No. 109									
Manure	Ridge	3775.2	145.20	5852.00	220.46	7524.00	289.38	5710.6	227.52
	Flat	5984.0	230.15	5280.00	203.07	4114.00	153.23	5075.1	195.49
Ash	Ridge	4840.0	186.15	4092.00	157.40	2464.00	94.77	3798.6	112.77
	Flat	5412.0	208.15			6424.00	247.07	5918.0	227.61
Mixed	Ridge	5632.0	216.61	3369.20	129.58	3537.60	136.00	4146.3	160.73
	Flat	4532.0	174.31	5280.00	203.07	4400.00	169.21	4734.0	182.26
Check	Ridge	3740.0	143.75	3907.00	150.00	3074.00	119.15	3540.3	134.30
	Flat	4360.0	167.54	4457.20	171.74	3256.00	125.23	4024.4	154.48

Average Ridge 4348.94 lbs.
Average Flat 4599.73 lbs.

TABLES III AND IV

YIELD OF MARKETABLE PODS COMPUTED TO ONE HECTARE BASIS

Variety Big Japan Coll. Number 3079 F3		*Native Plow* Pounds	Bushels	*Once-Deep Plowed* Pounds	Bushels	*Twice-Deep Plowed* Pounds	Bushels	*Averages* Pounds	Bushels
Manure	Ridge	4791.60	184.29	3960.00	152.31	4303.20	165.50	4351.60	167.33
	Flat	4884.00	187.84	4228.40	162.63	5913.60	227.36	5008.50	192.61
Ash	Ridge	4482.28	172.39	4895.00	188.17	4072.10	172.23	4483.12	177.93
	Flat	4400.00	169.23	3454.00	132.82	6644.00	255.50	4832.60	185.85
Mixed	Ridge	3766.40	144.86	1980.00	76.05	4928.00	189.54	3558.00	136.45
	Flat	4005.20	154.46	2004.04	77.09	5500.00	211.52	3836.00	144.35
Check	Ridge	3709.20	142.65	2453.00	94.34	3077.00	118.25	3046.00	115.08
	Flat	1909.60	73.49	3231.25	124.30	4708.00	181.07	3249.61	126.15

Average Ridge 3809.88 lbs.
Average Flat 4231.68 lbs.

Variety San Mateo Coll. No. 5958 F1									
Manure	Ridge	1980.00	76.00	5456.00	209.85	3766.40	144.86	3434.10	143.57
	Flat	5500.00	201.54	3872.00	148.92	5608.00	223.39	4993.00	191.10
Ash	Ridge	3740.00	143.84	3682.00	141.65	4708.00	181.08	4040.00	155.52
	Flat	5332.8	205.10	4730.00	161.92	3784.00	145.55	4615.60	174.19
Mixed	Ridge			3872.00	148.00	2596.00	99.85	3234.00	123.92
	Flat	3420.00	135.38	4048.00	155.69	4510.00	173.00	3992.60	154.69
Check	Ridge	2791.80	107.37	3102.00	119.31	4122.80	158.57	3335.50	128.41
	Flat	4368.54	165.52	3026.20	116.43	4483.60	172.45	3959.78	152.22

Average Ridge 3410.87 lbs.
Average Flat 4390.29 lbs.

TABLES V AND VI

YIELD OF MARKETABLE PODS COMPUTED TO ONE HECTARE BASIS

Variety Kinorales Coll. No. 3083 F2		*Native Plow* Pounds	*Once-Deep Plowed* Pounds	*Twice-Deep Plowed* Pounds	*Averages* Pounds	Average
Manure	Ridge	4761.25	2815.31	3436.13	3670.87	3962.90
	Flat	4252.88	3379.75	5132.19	4254.94	
Ash	Ridge	3320.63	3348.93	3628.25	3432.60	3322.75
	Flat	3306.88	2860.10	3471.88	3212.89	
Mixed	Ridge	3520.00	2554.06	2626.25	2900.10	3112.73
	Flat	3643.00	3616.82	—	3325.35	
Check	Ridge	2416.25	2664.44	3253.44	2771.34	2659.73
	Flat	2337.50	3148.10	2158.75	2548.11	

Average Ridge ....3193.20 lbs.
Average Flat .....3335.32 lbs.

Variety-Native Lemery Coll. No. 3082 F1						
Manure	Ridge	4083.20	2820.00	4180.00	3694.40	2964.80 lbs.
	Flat	2860.00	2703.94	2703.94	2781.20	
Ash	Ridge	2895.20	2068.00	1892.00	2285.06	3059.83 lbs.
	Flat	4554.20	—	3124.00	3834.60	
Mixed	Ridge	1870.00	1364.10	1760 00	1664.60	2052.30 lbs.
	Flat	2250.00	2794.00	2376.00	2440.00	
Check	Ridge	1858.05	1625.20	1940.00	1799.08	2328.74 lbs.
	Flat	2890.80	2250.00	2596.00	2868.40	

Average Ridge.....2721.57 lbs.
Average Flat.....2981.05 lbs.

TABLES VII AND VIII

TABLE SHOWING THE PERCENTAGES OF MOISTURE AND OIL CONTENT WITH DIFFERENT FERTILIZERS

Variety Big Japan Coll. No. 3079 F_3	*Native Plow* Moisture	Oil	*Once Deep Plowed* Moisture	Oil	*Twice Deep Plowed* Moisture	Oil	*Averages* Moisture	Oil	*Average on fertilizer* Oil
Manure...Ridge.....	7.97	48.86	7.09	49.99	6.63	52.39	7.23	50.41	50.06
Flat.....	8.62	49.85	7.05	—	7.20	49.60	7.62	49.72	
Ash.....Ridge.....	8.16	58.98	7.05	46.38	6.96	51.28	7.39	52.21	52.94
Flat.....	7.11	56.42	7.02	50.78	7.04	53.81	7.05	53.62	
Mixed.....Ridge.....	7.96	56.39	7.05	50.63	6.80	50.48	7.27	52.50	52.85
Flat.....	7.96	54.40	6.88	55.56	6.75	49.68	7.19	53.21	
Check.....Ridge.....	8.11	47.57	——	—	7.03	50.33	7.57	48.01	48.75
Flat.....	8.68	54.17	7.62	51.76	6.66	42.55	7.65	49.49	
Variety American Coll. No. 109 F_3									
Manure...Ridge.....	7.37	48.11	7.81	48.11	8.06	53.76	7.74	49.99	50.55
Flat.....	7.67	49.48	7.73	49.64	8.02	54.20	7.79	51.11	
Ash.....Ridge.....	6.89	55.50	7.83	53.16	8.52	52.82	7.74	52.29	52.25
Flat.....	6.37	55.51	8.79	48.41	8.90	52.71	8.05	52.21	
Mixed.....Ridge.....	7.86	53.31	7.35	49.26	—	—	8.33	52.36	53.68
Flat.....	7.87	60.50	7.95	51.67	8.64	52.91	8.15	55.01	
Check.....Ridge.....	8.12	51.50	7.92	48.12	9.94	30.51	8.69	43.34	47.38
Flat.....	8.29	54.62	6.72	51.02	8.74	48.53	7.91	51.41	

TABLES IX AND X

TABLE SHOWING THE PERCENTAGES OF MOISTURE AND OIL CONTENT WITH DIFFERENT FERTILIZERS

Variety Kinorales Coll. No. 3083 F_2	*Native Plow* Moisture	Oil	*Once Deep Plowed* Moisture	Oil	*Twice Deep Plowed* Moisture	Oil	*Averages* Moisture	Oil	*Average on fertilizer* Oil
Manure...Ridge.....	6.89	57.3	7.13	55.42	6.12	56.6	6.71	56.51	55.04
Flat.....	6.37	58.5	7.21	55.67	7.15	47.57	6.91	53.58	
Ash.....Ridge.....	7.12	59.00	6.42	54.20	7.31	59.88	7.95	57.69	57.45
Flat.....	6.40	58.00	7.32	56.20	6.80	58.33	6.84	57.21	
Mixed.....Ridge.....	6.70	58.7	6.70	56.30	6.35	52.62	6.58	55.87	57.40
Flat.....	6.55	59.00	6.38	57.30	6.18	60.50	6.70	58.93	
Check.....Ridge.....	7.10	55.10	7.4	58.30	7.15	57.78	7.22	57.15	57.40
Flat.....	6.72	56.6	7.13	58.50	7.13	57.85	6.99	57.65	
Variety N. Lemery Coll. No. 3082 F_2									
Manure...Ridge.....	6.37	50.74	6.30	50.05	6.28	49.52	6.32	50.15	49.91
Flat.....	6.57	48.35	6.50	50.30	6.26	50.35	6.44	49.66	
Ash.....Ridge.....	6.35	55.77	6.32	50.22	6.32	50.55	6.33	52.11	52.43
Flat.....	6.26	50.37	6.03	53.54	6.14	53.60	6.14	52.75	
Mixed.....Ridge.....	3.23	49.83	6.14	51.20	6.15	50.12	5.51	50.38	51.07
Flat.....	7.41	51.31	6.37	51.42	6.22	52.60	6.66	51.77	
Check.....Ridge.....	6.38	48.30	6.70	49.23	6.23	50.05	6.43	49.90	49.93
Flat.....	6.87	51.54	6.53	50.40	6.20	50.07	6.53	50.67	

TABLES XI AND XII

TABLE SHOWING THE PERCENTAGES OF MOISTURE AND OIL CONTENT WITH DIFFERENT FERTILIZERS

Variety Montalban Coll. No. 5957 F1		*Native Plow*		*Once Deep Plowed*		*Twice Deep Plowed*		*Averages*		*Averages on fertilizer Oil*
		Moisture	*Oil*	*Moisture*	*Oil*	*Moisture*	*Oil*	*Moisture*	*Oil*	
Manure	Ridge	5.88	53.57	9.01	52.37	6.81	54.63	7.23	53.52	52.67
	Flat	6.21	56.96	—	—	6.28	46.71	6.24	51.82	
Ash	Ridge	5.37	54.59	5.04	56.73	6.58	48.68	5.66	53.26	53.83
	Flat	6.31	56.68	6.13	53.40	6.15	53.14	6.19	54.41	
Mixed	Ridge	5.62	54.88	6.03	56.54	6.35	52.99	6.00	54.80	53.74
	Flat	6.31	55.01	—	—	6.19	50.18	6.25	52.59	
Check	Ridge	5.71	54.90	6.13	52.74	6.82	50.90	6.22	52.86	51.42
	Flat	6.18	48.75	—	—	6.15	51.00	6.16	49.88	

Variety San Mateo Coll. No. 5958 F1	
Manure	Ridge
	Flat
Ash	Ridge
	Flat
Mixed	Ridge
	Flat
Check	Ridge
	Flat

Weather Observation, August, 1917

July	Rainfall in mm. Daily 6. P.M.	Rainfall in mm. Weekly Total	Temperature in °C Maximum	Temperature in °C Minimum	Temperature in °C Mean Daily	Temperature in °C Mean Weekly	Wind in miles Daily	Wind in miles Weekly	Cloudiness	Atmometer Reading in cc. Evaporation Daily	Atmometer Reading in cc. Evaporation Weekly	Atmometer Reading in cc. Insolation Daily	Atmometer Reading in cc. Insolation Weekly
30	0.6		29.0	23.6	26.3		23.7		Cloudy	20.0		11.9	
31	1.4		29.0	23.8	26.4		52.7		½ "	22.4		12.6	
August													
1	T		29.5	23.7	26.6		41.2		Fair	25.4		12.6	
2	0		30.1	23.2	26.6		33.2		Clear	30.4		13.8	
3	0.5		29.0	24.0	26.5		43.0		½ cldy.	12.4		6.8	
4	17.2		26.1	23.7	24.9		15.9		Showers	1.2		2.4	
5	2.0	21.7	28.6	22.8	25.7	26.1	32.7	242.4	Cloudy	20.4	132.2	12.7	72.8
6	3.0		28.9	23.8	26.3		36.5		¾ "	22.6		8.7	
7	0.5		29.4	22.8	26.1		24.7		½ "	28.4		13.9	
8	4.3		28.3	23.8	26.1		37.7		½ "	16.2		23.2	
9	0.2		28.2	23.7	25.9		38.8		½ "	20.4		7.8	
10	0.2		29.9	23.0	26.5		40.3		¾ "	20.2		9.5	
11	0.5		29.4	24.5	27.0		36.1		½ "	25.4		5.2	
12	T	8.7	30.8	22.9	27.3	26.4	52.1	266.2	½ "	24.0	157.2	9.1	77.4
13	T		29.3	23.0	26.2		44.6		Cloudy	24.6		5.2	
14	0		30.8	23.4	27.1		45.3		¼ "	22.2		4.9	
15	1.4		30.8	24.7	27.7		78.0		½ "	23.6		4.8	
16	T		31.4	24.2	27.8		66.8		¼"	27.5		5.7	
17	3.2		29.6	26.0	27.3		120.5		Cloudy	36.7		12.3	
18	2.2		28.0	25.6	26.8		94.4		"	15.9		2.9	
19	8.2	15.0	28.4	23.8	26.1	27.0	41.1	490.7	"	13.6	164.1	3.0	38.6
20	0		28.6	24.6	26.6		27.1		¾ "	23.8		19.3	
21	2.0		30.2	24.4	27.3		37.0		½ "	21.2		7.9	
22	2.7		34.3	22.7	28.5		39.0		¾ "	21.9		7.0	
23	0		31.0	23.7	27.4		49.9		½ "	21.2		3.7	
24	0		30.8	24.1	27.4		43.2		¾ "	28.4		4.2	
25	0.8		30.9	23.6	26.8		37.8		½ "	15.5		9.4	
26	T	5.5	30.1	22.9	26.5	27.2	35.0	269.0	Clear	22.6	154.6	7.1	58.6
27	0		31.0	23.0	27.0		29.2		"	21.9		5.9	
28	2.2		31.4	24.1	27.7		41.3		Cloudy	27.6		5.0	
29	0.9		30.0	23.8	26.9		21.9		¾ "	21.9		8.1	
30	T		31.0	23.4	27.2		34.2		Clear	34.2		12.9	
31	4.2		29.1	23.8	26.5		28.8		¼ cldy.	21.9		4.9	
Month of August	56.2				26.8			1347.5		693.2		259.7	
Sept.													
1	15.3		29.0	23.5	26.2		28.8		½ cldy	25.5		7.9	
2	2.6	25.2	28.8	23.1	26.0	26.8	27.8	212.0	½ "	25.5	178.5	13.1	57.8

The above records were made by Vitaliano Ravara, under the supervision of the Botany Department. The atmometer readings show the daily rates of evaporation, from white and black porous clay spheres. Insolation, as here given, is the difference in rate between the black and the white spheres and indicates the intensity of the sunlight.

The month was somewhat dry, and was favorable for corn and other dry season crops. Rice suffered from drought. There were no high winds and the sky was usually more or less overcast, there being only five days recorded as entirely clear. Under these conditions evaporation was moderate, so that the effect of the lack of rain was less severe than is usually the case during dry months.

FORMAN T. MCLEAN.

Weather Observation, September, 1917

By V. Ravara

Sept.	Rainfall in mm. Daily 6 P.M.	Rainfall in mm. Weekly Total	Temperature in °C Maximum	Temperature in °C Minimum	Temperature in °C Mean Daily	Temperature in °C Mean Weekly	Wind-miles Daily	Wind-miles Weekly	Cloudiness	Atmometer Reading in cc. Evaporation Daily	Atmometer Reading in cc. Evaporation Weekly	Atmometer Reading in cc. Insolation Daily	Atmometer Reading in cc. Insolation Weekly
1	15.3		29.0	23.5	26.2		28.8		Cloudy	25.5		9.5	
2	2.6		28.8	23.1	26.0		27.8		½ cldy.	25.5		14.9	
3	2.0		31.0	22.8	26.9		25.8		Clear	17.8		3.6	
4	9.3		28.6	23.1	25.8		28.4		Cloudy	21.3		4.6	
5	18.5		28.0	22.8	25.4		32.5		¾ cldy.	13.8		7.5	
6	2.5		28.1	22.6	25.4		31.7		¾ "	13.3		7.6	
7	2.3	52.3	28.6	22.8	25.7	25.9	21.1	196.1	½ "	18.8	136.0	5.7	53.4
8	4.7		29.5	23.5	26.5		25.1		½ "	18.2		5.1	
9	4.6		26.5	23.8	25.1		16.6		Cloudy	9.0		8.4	
10	5.3		28.0	23.4	25.7		42.3		½ "	17.9		7.1	
11	2.6		28.0	24.2	26.1		46.9		½ "	11.0		7.4	
12	0.2		28.8	23.6	26.2		26.6		Fair	15.4		14.4	
13	0.3		29.6	23.0	26.3		28.1		½ cldy.	16.0		18.7	
14	1.4	19.1	27.8	23.6	25.7	25.6	29.4	206.0	¾ "	13.2	100.7	12.0	73.1
15	0.1		29.9	23.6	25.8		23.6		Clear	19.4		16.4	
16	0.9		28.2	24.0	26.1		15.4		¾ cldy.	12.0		10.2	
17	4.4		26.4	23.6	25.0		20.3		½ "	6.0		7.6	
18	0.6		30.0	24.0	27.0		29.7		½ "	19.6		17.0	
19	2.3		29.0	23.8	26.4		22.7		¾ "	15.9		13.6	
20	10.3		29.2	22.2	25.7		39.7		Cloudy	11.9		5.8	
21	1.8	20.4	27.7	23.7	25.7	26.0	28.6	180.0	"	10.0	94.8	9.7	80.3
22	14.5		27.8	23.2	25.5		14.5		Cloudy	7.8		5.8	
23	9.8		28.0	22.6	25.3		18.9		Clear	11.1		4.7	
24	16.0		27.1	23.6	25.4		29.8		Cloudy	8.0		9.0	
25	3.5		28.8	23.6	26.2		21.3		"	10.7		10.7	
26	1.7		28.0	22.7	25.3		23.2		¾ "	11.8		11.9	
27	10.4		28.0	22.8	25.4		24.5		Cloudy	8.9		11.1	
28	10.4	66.3	28.8	23.7	26.3	25.6	25.0	157.2	½ "	11.8	78.1	9.7	62.9
29	0.4		27.2	23.6	25.4		26.0		Cloudy	8.7	8.0	8.0	
30	6.3		27.4	23.7	25.7		25.3		"	7.7		6.6	
Month		64.8				25.8		790.6			416.9		284.3
Sept. College Coffee Plantation													
1–7		45.0	28.6	20.0		24.3					43.1		40.4
8–14		47.5	28.5	20.1		24.3					37.3		29.9
15–21		23.8	29.0	19.8		24.4					26.8		33.8
22–28		87.2	28.8	20.2		24.5					27.6		33.4
Sept. Summit of Mt. Maquiling													
1– 8		100.1	22.3	18.2		21.1					30.4		54.1
8–15		34.5	23.5	18.0		21.1					24.7		42.2
15–22		30.5	21.3	19.0		20.6					21.9		41.9
22–28		74.4	24.0	19.0		21.6					20.4		45.8

The above records for the coffee plantation and the summit, at approximate elevations of 325 meters and 1100 meters above sea level respectively, are made weekly on Saturdays. Temperatures at the coffee plantation are absolute maximum and absolute minimum for each week. Temperatures at the summit are read from a thermograph record and are averages of daily maxima and minima. These stations indicate that the rainfall increases, and temperature and evaporation become less as one ascends the mountain.

The weather conditions at the college during September were favorable for most crops which are adapted to the rainy season. The low wind velocities, relatively low temperatures and daily rains were as might be expected. The total rainfall, however, was moderate, as there were only six heavy rains, exceeding 1 centimeter. Also, there was more sunshine than is usual at this season.

F. T. Mclean.